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ABSTRACT

The purpose of this study conducted by the Wisconsin Research and Development Center for Cognitive Learning was to develop, implement, and evaluate an experimental preschool education program based on Piaget's theory of cognitive development. A second purpose was to examine Piaget's theoretical assumptions and postulated cognitive developmental trends for a two-year period of the preoperational substage. A core group of 48 subjects aged 3 to 5 years remained with the project for the full two years. The document includes sections on (1) the preoperational characteristics of mental operations, (2) description of preschool programs and the teacher education component which includes principles, guidelines and components of the Piagetian preschool program, a conventional nursery school program and the teacher education program for the Piagetian Preschool Education Program (PPEP), (3) methods and procedures, (4) results and discussion. Extensive tables are included. The 92 pages of appendices include curriculum planning materials, task protocols, scoring procedures and materials as well as comprehensive score patterns and stage designations for the complete task battery. (MS)

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Technical Report No. 354
(Part 1 of 2 Parts)

LOGICAL OPERATIONS INSTRUCTION IN THE PRESCHOOL

by

Ann M. Bingham-Newman, Ruth A. Saunders,
and Frank H. Hooper

Report from the Project on
Conditions of School Learning and Instructional Strategies

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PS 009072

Wisconsin Research and Development
Center for Cognitive Learning
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April 1976

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Final Report--Hatch Research Project 142-1769
July 1, 1971, to August 30, 1974

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WISCONSIN RESEARCH AND DEVELOPMENT
CENTER FOR COGNITIVE LEARNING

MISSION

The mission of the Wisconsin Research and Development Center for Cognitive Learning is to help learners develop as rapidly and effectively as possible their potential as human beings and as contributing members of society. The R&D Center is striving to fulfill this goal by

- conducting research to discover more about how children learn
- developing improved instructional strategies, processes and materials for school administrators, teachers, and children, and
- offering assistance to educators and citizens which will help transfer the outcomes of research and development into practice

PROGRAM

The activities of the Wisconsin R&D Center are organized around one unifying theme, Individually Guided Education.

FUNDING

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1971-72, Wave 1--Ann M. Bingham-Newman, lead teacher; Nancy Sheehan, assistant teacher, T.A.; Ruth Saunders, research coordinator, R.A.; Rosie McMahon, tester; Virginia Newman, tester; and Tom Toniolo, tester.

1972-73, Wave 1--Ann M. Bingham-Newman, lead teacher; and John DeFrain, assistant teacher, R.A.

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Wave 2--Ruth Saunders, lead teacher; and Denise Bielby, assistant teacher, R.A.

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ABSTRACT

This research represents a direct attempt to integrate developmental theory with the more applied field of education in order to achieve a more thorough understanding of each. The study had two major foci: (1) to develop, implement, and evaluate an experimental preschool education program based on Piaget's theory of cognitive development, and (2) to examine Piaget's theoretical assumptions and postulated cognitive developmental trends for a two-year period of the preoperational substage. Aspects of cross-sectional and longitudinal designs were incorporated into the pretesting and posttesting of two overlapping waves of experimental and control group populations of preschool children over a period of three years.

A core group of 48 subjects, aged 3 to 5 years, remained with the project for the full two-year period desired for each wave. The subjects were evaluated with two standardized measures--Peabody Picture Vocabulary Test (PPVT) and RAVEN Coloured Progressive Matrices (Raven CPM)--and a representative battery of eight Piagetian tasks. The differences in developmental patterns between the experimental and control groups were examined with tasks of seriation, classification, transitivity, conservation, measurement, and class inclusion and with two matrix tasks (double seriation and cross-classification). Within the general area of the acquisition of cognitive abilities, normative longitudinal and cross-sectional analyses were utilized to examine within-stage intra-individual performance correspondences, developmental sequences in task performances, experimental and control group differences, and sex differences in task performance. In this research the assessment of children's thought processes was of more concern than the accumulation of pass/fail data.

The experimental group program included a teacher education component and a framework for curriculum decisions guided by nine principles from Piagetian theory. It focused on the understanding of seriation, classification, number, and spatio-temporal relations in a wide variety of spontaneous, yet integrated, experiences. Integrated experiences here refer to what Wohlwill (1970), and Strauss (1972) claim lead to optimal development of logical operations--that is, the development of operations in conjunction and collaboration with one another as part of a total structure rather than in isolation. The control group attended a conventional preschool.

Cross-sectional analyses using the Goodman-Kruskal gamma statistic indicated no outstanding differences between the performances of the experimental and control groups. Longitudinal analyses using the gamma statistic revealed significant gains on several of the Piagetian tasks and subtasks for both groups. In general, normative analyses indicated typical performance patterns for three- and five-year-old subjects, with a notable degree of individual differences in patterns of performance

and absolute level of performance. Pretest to posttest *t*-test comparisons of the non-Piagetian measures revealed significant gains for all subjects on the PPVT and for only the Wave 2 control group on the Raven CPM.

An analysis of within-stage correspondence, within and across concept domains, indicated a notable lack of synchrony, with many individual patterns in both the experimental group and the control group. These results are supportive of previous work by Flavell (1971), Turiel (1969), and Wohlwill (1973b) which suggests that a high degree of structural mix in response patterns can be expected during the transitional preoperational period. Pretest responses often clustered in Stage I, while posttest responses were generally spread across all response categories (i.e., Stages I, II, and III with associated substages). Sex differences were found for the non-Piagetian measures but were notably absent in the Piagetian measures. A time-lag analysis was performed to reveal any evidence of causal linkages from performance on one task at the pretest to another task at the posttest. Very few of these comparisons were statistically significant. However, very different predictability patterns were found for the experimental and control groups. Because of this factor, unequivocal inferences about predictability for the present treatment conditions during the preoperational period cannot be made.

Although Piagetian theory provided a very workable and stimulating foundation for a preschool curriculum, program effects in this research were greatly overshadowed by the large amount of individual variation in the rate and sequence of cognitive developmental acquisitions in the preoperational stage. The almost complete asynchrony evidenced in the development of various operations assuredly brings into question those interpretations of Piagetian theory that depend on synchronous emergence and cohesive, well-integrated structures at all stages of development. This research suggests that, regardless of how synchronously operations develop in later stages, they follow a more diverse pattern in the preoperational stage.

I

INTRODUCTION

The period of development between ages two and seven or eight years is what Piaget calls the period of preoperational thought. There are several aspects of preoperational thought that make it difficult for the child to function logically. These idiosyncrasies necessarily determine the types of experiences that can be expected to benefit the preoperational child. Knowledge of the cognitive structures of the young child and of the processes or operations that are the structural underpinnings of the successful grasp of typical subject matter should make possible the formation of a learning environment that is effective in helping to promote the further construction of operational abilities by the child. The development and evaluation of such an environment were integral parts of this research.

Characteristically, the child at the beginning of the preoperational period is learning to use language to represent objects and events. Mental symbols enable him/her to recall things that are not in his/her immediate environment. The operational abilities of classification, seriation, measurement, transitivity, and conservation are becoming increasingly organized and operable during this period. Flavell (1963) characterizes the change from the beginning of the preoperational period to the latter part as a time when rigid, static, and irreversible structures, typical in the early part of the period, begin to become more flexible, mobile, decentered, and reversible. The irreversible aspect of preoperational thought is striking. For example, the preoperational child does not have the conservation abilities that Piaget believes are necessary for logical thought; she/he is not aware of the invariant properties or attributes of objects or situations that undergo irrelevant transformations.

The preoperational child is often misled by the way things appear at any given moment. This centration includes the tendency to focus on only one attribute of an object at one time, e.g., on height without considering width, instead of coordinating the variables. Usually, the variable that the child centers on stands out visually. Because she/he cannot coordinate more than one variable, she/he cannot understand the principle of conservation (invariance in the face of irrelevant perceptual change). The child does not yet have the internal system of regulations that can compensate for external changes (Furth, 1969). Very often the preoperational child observing a sequence of change will focus only on a particular state in the transformation rather than on the process itself. Though the preoperational child may realize that reversibility of actions is possible, mental actions cannot yet compensate for apparent discrepancies in the perceived information (Ginsburg & Opper, 1969).

The child at this stage is also what Piaget describes as egocentric, finding it difficult to understand that other people may view things differently than she/he does. She/he relies on his/her own immediate perception, ignoring both his/her own previous perceptions and the varying perceptions of others. This egocentrism is apparent in his/her understanding of the interests, needs, roles, and feelings of others as well. Gradually, the preoperational child becomes less egocentric, can focus on several aspects of a situation or object at once, follows a dynamic process instead of focusing on a static state, and is able to reverse the direction of his/her thinking. At this point, she/he begins to form organized and integrated systems of operations with which she/he can deal with the world.

The present research examines the development of these systems. Of primary consideration were ascertaining what kinds of experiences are important for cognitive growth and determining in what manner experience in a program derived from Piagetian theory affects the changes in the reasoning processes of the preoperational child.[1] The program that was developed, implemented, and evaluated in this research was based on several principles of Piagetian theory. It focused on the understanding of seriation, classification, number, and spatio-temporal relations in a wide variety of spontaneous, yet integrated, experiences. Emphasis was placed on critical thinking; simple and reflective abstraction; alternative ways of problem solving; individual initiation of learning experiences; intellectual honesty; and appropriate, empathetic social interaction with peers and adults. The use of an integrated curriculum framework implies that the optimal development of logical operations is considered more likely when operations develop in conjunction and collaboration with all other operations and as part of a total structure than when they develop in isolation (Strauss, 1972; Wohlwill, 1970). With this approach, spontaneous experiences, initiated by the child in an environment of a variety of alternative activities,

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[1] Since a considerable number of recent reviews of the Piagetian training research literature are available (e.g., Beilin, 1971; Brainerd, 1972; Brainerd & Allen, 1971; Glaser & Resnick, 1972; Hooper, Goldman, Storck, & Burke, 1971; Klausmeier & Hooper, 1974; and Wohlwill, 1970, 1973a), references to these findings will be brief and given in the context of specific abilities. This is not to imply that controversy is nonexistent (cf. Brainerd 1973a, and Strauss, 1972) or to question the role of such efforts in providing insight into developmental processes and theoretical constructs. The present study, however, is not to be confused with the standard training research paradigm. In contrast to such research, in which very specific procedures are used in teaching particular concepts, this program attempts to incorporate general theoretically derived principles into all aspects of a preschool program. In addition, a minimum of teacher-directed structure in the preschool program and the incorporation of theory into cognitive, socio-emotional, and psychomotor domains distinguish this program from other endeavors to apply Piagetian theory to the classroom environment (e.g., Furth & Wachs, 1974; Kamii & DeVries, 1974; Lavatelli, 1970, 1971; Sprigle, Van De Riet, Van De Riet, & Sprigle, 1969; Weikart, Rogers, Adcock, & McClelland, 1971; and Willis, personal communication, 1973).

are considered more appropriate for fostering cognitive development than the very specific, teacher-directed activities utilized in some programs. Piaget maintains that the child must actively construct his own knowledge and that good pedagogy must involve presenting the child with situations in which he can experiment in the broadest sense of the term. Therefore, one alternative to the "American question" is to help the child establish the processes or intellectual tools underlying cognitive functioning across a wide range of situations, thus expanding his/her intellectual potential.

During the three years of the present research project, the following were done in the Piagetian preschool program:

1. A coded card file of approximately 200 specific small group activities designed to enhance the child's development of thinking processes in the areas of classification, seriation, number, space, time, measurement, and representation was produced.

2. A list of approximately 200 conversation topics designed to challenge young children's thinking was completed.

3. A set of 55 weeks of daily curriculum plans covering a two-year period was completed and implemented for two overlapping waves of subjects.

4. A teacher education program for teachers planning on working in a Piagetian classroom was designed and used. This program includes:
   a. An intensive two- to three-week workshop for graduate or undergraduate credit.
   b. A two-semester seminar course for graduate or undergraduate credit to be given in conjunction with practical experience.
   c. A program for the practicum with discussion topics, observation assignments, self-development goals, and provisions for various kinds of evaluation.

5. Various materials dealing with methods and techniques implied by the theory for teaching were developed to supplement text material.

6. A battery of tasks designed to evaluate the developmental changes associated with the Piagetian curriculum was developed and refined.

7. A procedure to train testers to administer and score the task battery was designed and implemented.

8. An analysis of data for two overlapping waves of children--both experimental and control groups--was completed.

The present study provides information on cognitive developmental changes that occurred during a two-year period of the preoperational substage in children in the Piagetian preschool program and children in a conventional preschool program. It also reports on the effectiveness of the Piagetian preschool program.

II

PREOPERATIONAL CHARACTERISTICS OF MENTAL OPERATIONS

The operational abilities with which the present study is primarily concerned are seriation, classification, cross classification, transitivity, double seriation, conservation, and measurement. Within each ability there is a characteristic pattern of developmental acquisition that can aid the educator in organizing and interpreting experiences for young children.

SERIATION

Seriation, the ability to arrange elements in an ordered series according to changes along a particular dimension, such as size, color, or weight, is one of the operations that develops during the preoperational period. The typical order of development in seriation, as defined by Piaget (1952), is as follows: First, the child arranges the items into groups of two or three but cannot coordinate all of the items into a single series. It seems that the child at this point has only a global impression of a series of items. Next, the child, by trial and error, arranges and rearranges the items until they are in a single series but cannot insert a second set of items into the original series. Finally, the child approaches the task with a systematic method; she/he places the smallest (or the largest) item first and then the smallest (or the largest) of those that remain, and so on, and she/he can also add items to the original series. The systematic method finally used indicates that the child understands that an item can be larger than one item yet smaller than another; this is the essence of seriation and a form of reversibility (Piaget & Inhelder, 1969). When the child can construct orderings, put two orderings in one-to-one correspondence, and conserve the resulting equivalence, he has formed an integrated and comprehensive structure. Elkind (1964) replicated Piaget's original seriation experiments and confirmed Piaget's hypothesis of three stages in the development of seriation. Although Elkind's study confirmed a general sequence of development, it also indicated individual departures from the sequence--especially when task materials are considered. Siegel (1974) questioned whether there actually is a "preoperational" stage in the development of seriation because in her research she found it necessary to look at very young subjects (age three years) before she found the type of responses associated with the preoperational stage.

CLASSIFICATION

The ability to choose criteria and to exhaustively sort objects into mutually exclusive groups is a classification ability which develops fairly late in the preoperational period. In Inhelder and Piaget's (1969) view, however, true classification ability involves the additional understanding of class inclusion relations and does not appear until the concrete operational period. Such relations involve quantitative comparisons of subcategories to superordinate categories in a hierarchy. The developmental acquisition of classification abilities as defined by Piaget (see Ginsburg & Opper, 1969) is divided into three stages. Initially, the child is unable to coordinate intensivity (similarities among objects) with extensivity (the number of objects sharing the similarity); so his/her collections are not true classes but rather "jumbles" of objects lacking a single attribute common to all the members of the collection. Later, the child is able to form classes of objects and to create hierarchies but still cannot understand the relationships between parts in the hierarchy. She/he might arrange a set of blue circles in a group of circles of different colors without comprehending that there must of logical necessity be more circles in the set of all circles before him/her than in the set of blue circles alone. True operational classification ability is said to be present when the child understands both exhaustive criteria-based sorting and class inclusion. The latter, according to Brainerd (1973b) and Hooper, Sipple, Goldman, and Swinton (1974), appears after the development of conservation abilities, generally in children well into the grade school years.

A number of examinations of the parallels between classification and seriation abilities have been made. Lovell, Mitchell, and Everett (1962) found synchrony in the developmental patterns of the two areas. Several others, however, found definite asynchrony (see Hooper et al., 1974; Lagatutta, 1970; MacKay, Fraser, & Ross, 1970). Differences in findings may be heavily dependent on the specific task formats used. Wohlwill (1968) for example, found differences in performance when verbal and pictorial presentations were compared. Also, Inhelder and Piaget (1969) have maintained that the more abstract a presentation is, the more difficult the task becomes for the child.

CROSS CLASSIFICATION

The ability to sort objects on two variables simultaneously, cross classification, is frequently assessed with a matrix task in which rows represent one variable (e.g., shape) and columns another (e.g., color). In such a task the child may be shown a completed block matrix and then asked to reproduce the arrangement shown after all the blocks have been removed. Following the reproduction portion of the task, the transposition problem is presented. In this portion of the task, the child is asked to reconstruct the matrix after all of the blocks have been removed and one of the corner blocks has been relocated on the matrix board so as to rotate the arrangement.

Theoretically, cross classification ability should emerge in synchrony with class inclusion understandings and both should emerge at about the same time as double seriation abilities (Inhelder & Piaget, 1969). Conflicting findings concerning these relationships have been discussed above. Brainerd (personal communication, 1974) has suggested that the colors used in the classification matrix may be considered by some children as a continuous variable along a brightness dimension. It is also possible that some children see the shape distinctions in a similar fashion, with the number of corners as the continuous dimension. Individual differences in task perception may account for the lack of consistent findings of either synchrony or asynchrony.

TRANSITIVITY

The ability to recognize the relationships A > B and B = C leads to another aspect of ordinal relations, namely, transitivity. Transitive reasoning allows the child to conclude that given these relationships, A > B and B = C, the relationship between A and C must be A > C.

Piaget, Inhelder, and Szeminska (1960) confirmed that the understanding of serial order is prerequisite to transitive understanding of size relationships. This relationship was further supported by the research of Murray and Youniss (1968). Braine (1959), however, found nonconfirming evidence in this regard. In Piagetian literature, transitivity is considered to be a measure of inferential reasoning. Piaget hypothesized that the principles of conservation and transitivity develop simultaneously with respect to a given content area. Lovell and Ogilvie (1961) found evidence that transitivity preceded conservation in a study of conservation of weight in the junior school child. Brainerd (1973b) and Toniolo and Hooper (1975) found that the development of transitivity preceded the development of conservation and class inclusion. This is in contrast to a previous finding (Smedslund, 1963) that conservation of length preceded development of transitivity of length. Problems in the relationship of transitivity to other areas of logical thought are compounded by problems in the study of transitivity itself. Smedslund (1963, 1965) and Braine (1959, 1964), for example, carried on a lengthy controversy over the results of Piaget's transitivity work and finally agreed that methodologically adequate and more relevant data were needed before conclusions could be drawn.

DOUBLE SERIATION

Inhelder and Piaget (1969) hypothesized that simple seriation and multiple seriation appear at approximately the same time. Multiple seriation may be assessed in a matrix format with series ordered along the horizontal and vertical axes, i.e., two asymmetrical transitive relations (Inhelder & Piaget, 1969). Cross-sectional studies of multiple seriation development suggest the following sequence of task performance: First, there is a lack of any true seriation (e.g., the child may make graphic alignments that could as easily be classes

as series). Next, the child seriates one of the two variables while ignoring the other or attempts to seriate both variables but fails because she/he thinks of the two seriations as on different planes instead of coordinating them. Finally, she/he seriates both variables simultaneously. MacKay et al. (1970) investigated the development of multiple seriation and multiple classification with a 3 x 3 matrix task and found that the multiple classification task was passed by a larger percentage of young subjects than the multiple seriation task. The reproduction task was also easier (passed by more subjects at younger ages) than the transposition task. Using cross-sectional data and the percentage of subjects at each age level who passed the task, Hooper et al. (1974) also found evidence suggesting that for the reproduction task, cross classification abilities develop before double seriation abilities. However, they found that for the transposition task, the multiple seriation format was easier than the cross classification format.

CONSERVATION

Piaget and Inhelder (1969) point out that at the preoperational level reactions to conservation problems are centered on perceptual cues or imagined configurations, while at the operatory levels reactions are based on identity or reversibility. Conservation is considered to be the beginning of significantly more complex intellectual activity. This notion of invariance is essential to any kind of measurement in the physical world (Lovell & Ogilvie, 1960). Piaget maintains that conservation ability develops in three distinct stages. First, there is nonconservation; in this stage the child is perceptually oriented. Then, there is a period of transition in which the child may conserve at one moment but is apt to lose the idea the next and usually cannot verbally explain his/her reasoning. Finally, the child can conserve and support his/her conclusions verbally. Lovell and Ogilvie (1960) confirmed Piaget's hypothesis of three stages in the development of conservation abilities. Elkind (1961) and Uzgiris (1964) found that conservation of quantity followed Piaget's postulated developmental sequence of mass, weight, and volume. Although the sequence of development seems to be supported, stimulus complexity, stimulus materials, and task format have been found to influence the variability of responses in the transitional phase (see also Lovell & Ogilvie, 1961; Murray, 1969; and Schwartz & Scholnick, 1970).

Piaget seems to consider the three conservation tasks in the present study, that is, number, length, and substance, to be of equivalent difficulty (Wohlwill, Devoe, & Fusaro, 1971). Brainerd and Brainerd (1972) found that the familiar number-then-quantity conservation sequence was much less apparent when explanations were employed than when only judgments were employed. Wohlwill et al. (1971) hypothesized that conservation abilities might be the by-product of spontaneous overt activities in which children relate stimuli to each other along a particular dimension. They felt that this type of activity was common in the course of everyday life.

MEASUREMENT

The ability of the child to compare items along a particular dimension, e.g., height, length, and area, involves measurement. Wohlwill et al. (1971) label this process dimensionalization and state that once children develop ways of relating items in this way they may be expected to incidentally recognize the conservation property as it applies to those items. Wohlwill, Fusaro, and Devoe (1969) did, in fact, find evidence that early success on measurement tasks was related to later success on conservation tasks.

Measurement operations are referred to as infra-logical (Inhelder & Piaget, 1969) because they relate to a spatio-temporal level of reality, i.e., continuous objects, separations, and proximities. Measurement involves the recognition of the constancy or standardization of the unit as it is applied successively and without overlapping to the whole.

III

DESCRIPTION OF PRESCHOOL PROGRAMS AND TEACHER EDUCATION COMPONENT

PIAGETIAN PRESCHOOL EDUCATION PROGRAM

Principles and Guidelines

The Piagetian program was guided by general principles drawn from Piaget's theory of intellectual development. These principles provided a solid foundation for program goals and implementation. The following principles furnished the framework for the Piagetian Preschool Education Program (PPEP).

1. Intelligence is more than the mere accumulation of facts; it is the incorporation of the given data of experiences into an organized framework. It involves the individual's ability to organize and adapt, through the reciprocal processes of assimilation and accommodation, to various aspects of the environment.

2. Intelligence is developed through interaction between the environment and the individual. Timing and quality of interactions with the environment are important factors for an evolving intellect.

3. Growth of intelligence enhances functioning in all areas of psychological development, including affective, cognitive, and psychomotor development.

4. Learning is an active process, subordinate to development, that involves manipulative and exploratory interaction with the environment in the search for alternative actions and properties applicable to objects and events. This process involves both mental and physical activity.

5. Each stage in the development of intelligence is characterized by the presence or absence of specific cognitive operations. Children think about the world very differently than adults do, and they make different interpretations and draw different conclusions from given events.

6. There is an invariant sequence of development through the major periods of cognitive growth: sensorimotor, preoperational, concrete operational, and formal operational and the within-stage subsequences associated with the various concept domains. Each individual moves through the sequence at his own pace.

7. Language helps to focus on concepts and to retrieve them. It does not in itself build concepts.

8. Intellectual growth is fostered by social interaction with peers and adults as well as by interaction with the physical environment.

9. Autonomy with cooperation, rather than simple obedience to authority, contributes to the child's intellectual and moral development.

In defining goals for the PPEP, emphasis was placed on the development of intelligence. However, as implied in principle three, it is equally important to emphasize the rapprochement between the cognitive, affective, and psychomotor domains of behavior. Cognitive functioning in a particular situation is necessarily subject to one's emotional and physical condition. Likewise, the ability to deal with the emotional and physical aspects of a situation depends on one's intellectual capabilities. The influences are reciprocal throughout the course of development. Therefore, emotional and physical development are major concerns in the program and the PPEP goals apply to all three domains.

The long-range goals for teachers and children in the PPEP were directed toward facilitating the development of a particular kind of individual. Desirable characteristics of children and adults are the same, although the expression of these characteristics will differ with age. The program endeavors to help develop an individual who:

1. Relates intellectually, flexibly, and creatively to his/her environment.

2. Looks for alternative ways of solving problems.

3. Is able to initiate his/her own learning experiences by exploring, experimenting, and asking questions.

4. Has confidence in him/herself.

5. Is a critical thinker--does not accept the first answer given as the only answer or the right answer without checking it out (see Duckworth, 1964, p. 5).

6. Interacts empathetically and appropriately with peers and people in other age groups.

To help the child relate to his/her environment the PPEP focused on four content areas: logico-mathematical knowledge, infralogical knowledge, knowledge of the physical environment, and knowledge of the social environment. It should be noted that while these types of knowledge can be viewed as distinct and independent, they develop in each child in conjunction and collaboration with one another. Short-term goals or guidelines within the content areas were incorporated into a wide variety of experiences utilizing many types of materials.

It must be emphasized that these goals are stated as general goals for preschool children in the cognitive areas outlined by Piagetian theory. They are used as guidelines for the program, not as end-points or behavioral objectives for each child's preschool experience. They define a range of expectations for preschool children without imposing group goals on individual children. The guidelines are flexible and individualized; they take into account situational variables such as materials, space, time, number of children involved, developmental level of each child's interactions, and interests of the children.

The content areas and their associated short-term guidelines are as follows:

1. Logico-mathematical knowledge is the knowledge of relationships between and among objects, people, and events in the environment. This is the type of knowledge that must be reinvented in each child's thinking through the child's own actions and logic. Mobility of thought is an important aspect of logico-mathematical knowledge.

   Guidelines

   Classification--ability to:

   a. choose criteria for grouping
   b. group objects, ideas, people, events, etc.
   c. sort objects, ideas, people, events, etc.
   d. rearrange systems for grouping (horizontal reclassification)

   Seriation--ability to:

   a. recognize relative differences between two or more things
   b. order five or more objects in a consistent manner

   Number--ability to:

   a. equate equal numbers of objects (cardination with five or more objects)
   b. recognize that four is greater than three is greater than two, etc. (ordination)
   c. place five or more objects in one-to-one correspondence (spontaneous correspondence)
   d. conserve number with five or more objects

2. Infralogical knowledge is the knowledge of abstract, logical operations and related measurement abilities dealing with the concrete, physical world of positions, locations, distance, and time sequences and durations.

   Guidelines

   Space and time--ability to:

   a. maintain direction and consistent sequence in copying a linear order of five or more objects
   b. take a perspective in establishing a straight line between two points
   c. note the difference in viewpoints from different positions in space

d. recognize part-whole relationships in terms of spatial configurations
e. understand time relationships in four or more sequential events
f. differentiate time intervals

3. Physical knowledge is the knowledge of attributes and properties of materials in the environment discovered through repeated encounters with the natural environment. This area includes knowledge of physical phenomena such as causality and gravity. Physical knowledge is acquired through acting on objects and noting the effects.

Guidelines

Ability to:

a. be active both mentally and physically, expanding the repertoire of possible actions and increasing the information obtained from possible responses
b. ask questions
c. predict outcomes
d. make use of one action for a variety of solutions and make use of a variety of actions for one solution

4. Social knowledge is the cultural use of language and social expectations and conventions that are learned through feedback from people in the environment.

Guidelines

Ability to:

a. recognize appropriate social behavior
b. move away from egocentrism toward an empathetic relationship with others

Short-term goals for teachers are described in depth in Saunders (1976, in preparation).

Components

The daily schedule for the PPEP followed a typical two and one-half hour nursery school timetable and included arrival and free play (60 minutes), clean up and bathrooming (15 minutes), juice time (15 minutes), large-group meeting (20 minutes), small-group activity (15 minutes), and outside play (25-30 minutes). The sequencing of the components of the schedule was changed from time to time to provide variety and increase effectiveness. The outdoors was utilized as an extension of the classroom. After children became familiar with the surroundings, inside-outside days, in which children and teachers used both areas throughout the day, were common.

Free play. The classroom was arranged into interest areas where during free play children were free to choose from a variety of activities and materials planned and set out by the teachers, initiate activities, or request materials for their own ideas. The interest centers consisted of art, music, science and animals, children's literature and bookmaking, large motor activities, dramatic play, and small manipulative activities. In this regard and others, the PPEP was similar to an open classroom. However, in the PPEP events could be interpreted and dealt with in terms of the theoretical framework of principles and goals, which greatly aided the teachers in understanding what occurred in the classroom.

Most of the free-play activities were planned a week ahead of time by student teachers involved in the PPEP. (See Appendix A for two samples of weekly planning.) While some activities were long-term projects lasting for a week or more, most areas of the classroom changed activities every few days. Great effort was made to integrate learning in one area with learning in other areas. Art experiences using play dough, for example, could carry over to a bakery set-up in the dramatic play area and to science experiences in mixing ingredients and in the effects of heat on the dough. Classification, seriation, and spatio-temporal understanding were involved as a child gathered the number of various sized blocks he needed to solve spatial problems in his construction. Children were encouraged to work together to discover the physical knowledge inherent in the environment. During a typical free-play period, some children would work on one activity only, while others would partake of many activities. The only condition was that a child leave the area she/he was through with in some semblance of order before moving on.

In planning activities for the interest areas of the classroom, everything in the environment was viewed as a resource for knowledge. Planning consisted of writing plans and extensively discussing these plans. It included thinking through possible responses by the children to the activities. By being aware of what possibilities each activity held in terms of the theoretically derived framework of principles and goals, the teachers were prepared to respond to a variety of reactions on the part of the children. The teacher's main task was to be continually aware of the theoretical implications of the child's actions and interpretations of events in order to ask open-ended questions. This approach allowed the children to extend their activities and their thinking and reasoning capabilities--in short, to create and use spontaneous situations for learning. Teachers were prepared to pursue different avenues of learning as they were indicated by the actions of individual children within a particular activity. Each activity was viewed as having potential for learning in all four areas of knowledge.

The program required that the teachers ask open-ended questions since, according to the theoretical framework, there were no right or wrong answers because the children were at varying stages of development. Rather, there were alternatives. S. Papert (as quoted in Kamii & Peper, 1969), one of Piaget's colleagues, stated, "the child because of his egocentric view of the world always answers correctly the question he asks himself." Differences in answers and styles of problem

solving in the physical environment and in personal interactions were treated as highly valuable deviations.

In order to learn about the child's processes of thinking and his/her stage of development, teachers encouraged the child to give the answers she/he viewed as correct. If a child's answer was absurd from an adult viewpoint, situations were created in which the child could explore the problem and discover the answer from various alternatives, that is, from objects and events that did not permit his/her original conclusion. The child was therefore constructing his/her own knowledge and was confident of his/her own views.

The classroom was viewed as a workshop with a variety of materials and activities for children and teachers. Teaching and learning were seen as shared processes. The schedule of the day, the areas of the classroom, and the activities that were planned were always flexible and open to spontaneous ideas. However, exposure of children to materials was not considered sufficient. It was the teacher's responsibility to lead

> the children to an increasingly clearer understanding of connectives, similarities and differences, and movement of experiences through time, cause and effect relationships, and, as they matured in their intellectual capacities, the relationships between evidence and proof, between behavior and motivation, between facts and opinions. By helping the child penetrate experiences, concrete and abstract, to the level of relationships, the [teachers were] preparing children to order and deal with their world in terms of their society's logic and perception of reality [Biber, 1972, as cited by Diamond, 1973, p. 3].

In creating this type of environment, two forces were considered to be important: (1) the effect of each child's uniqueness on his/her learnings and (2) the contributions of each teacher as an individual in influencing the nature and direction of learning. What is done by the teacher and the child cannot be separated from who does it. By using the theoretical framework and planned activities as a guide, the program freed both teachers and children from an imposed curriculum that did not fit the situations or the persons involved.

Clean-up time. The potential for learning experiences was considered to be high during clean-up time. Children were encouraged to work together in cleaning up an area, thus increasing the possibility for peer teaching. The opportunities for using clean-up time to help children use the cognitive processes focused on by the PPEP were many. Classification of materials, e.g., blocks, dolls, dress-up clothes, art materials, and scissors, is important for effective storage. Seriation helps a child when she/he is putting the biggest things in one place, the smallest in another, and the medium-sized objects in a third place. A child needs spatial reasoning to find an object of a particular size to fit a given space or to know that something will not fit a chosen space. Measurement can be used in determining which thing will fit a particular space. Having each child find five things to put away and then five more was a favorite way to clean up.

Sometimes children showed the beginning of conservation processes during this clean-up task. For instance, one child put five unit blocks in one pile and five in another but noticed that one pile was taller. Teachers participated in clean-up time by both physically picking up with children and taking opportunities to strengthen processes. For example, in the above situation a teacher might have said to the child, "How could we be sure there are five in each pile?"

Juice time. During juice time, which lasted about 15 minutes, teachers and children had a snack and engaged in conversation. Topics of conversation were planned each week for teachers to use at their discretion. (See Appendix A for a sample of juice time topics.) With the cognitive processes clearly in mind, teachers could take advantage of the particular interests of their group at this time. Children and teachers were free to sit at whichever juice table they desired, and combinations of children, as well as of children and teachers, varied from day to day. Often conversation topics focused on typical egocentric thinking and reasoning of young children and were, thus, a type of formative evaluation. One such topic was, "If you were sitting in _____ chair, what could you see?" Sometimes the conversation topics were thinking games in which children used their imaginations or needed to make a decision; for example, "If I could be an animal, I would be a _____" and "If I were as tiny as an ant I would _____." The children were not required to partake in these conversations but usually everyone did. After a time children started initiating the games themselves.

In addition, juice time posed other opportunities for highlighting cognitive processes. One-to-one correspondence was used when children passed out one cup for each person or when each person found a chair. Physical knowledge was acquired from actions performed on food; for example, the children found that biting a carrot stick is very different from biting a marshmallow, that straws require different drinking action from that used with a cup, and that cookies break into distinct pieces while a muffin crumbles. The possibilities for using juice time as a learning experience were innumerable.

Large-group meetings. Large-group meetings were used as a time for children and adults to develop a community feeling. Children and teachers sat together on a large rug or outside. Sometimes plans for an upcoming trip were reviewed in story form or teachers told stories that needed children's ideas or responses to be complete. At other times a problem that affected the whole group was discussed, or the day's activities were reviewed and shared. Movies and tape recorders were incorporated to add different dimensions. Songs, movement, and games were common large-group activities. Sometimes when a project that had been started during free play required extra attention, a small group split off from the larger group to finish it or the large group was called upon to help; in one such situation, everyone was needed to help knead bread dough. The large-group meeting gave everyone an additional awareness of being part of a total group. All children were encouraged to join and remain in the group, but they were not required to participate in whatever activity was occurring.

Small-group activities. Small-group activities were planned by the lead teachers and the researchers. For these activities the children were divided into four groups of five children each, and one teacher

was assigned to each group. The groups were arranged so that each was made up of children who could compatibly work together. When teachers sensed that a grouping was not the most beneficial to the children involved, the groupings were rearranged. The same teacher remained with a particular group of children for a semester. Each group found a quiet corner of its own in which to work. Teachers were encouraged to stress that this was a work time as well as a special time to be together. Each group was encouraged to make its particular location uniquely its own with pictures, etc. Children were required to be with their group at small-group time but were not required to participate. Usually, when a child initially showed disinterest, it took only a few minutes for him to begin to participate on his own. Four small-group activities were chosen each week and rotated from group to group over the four weekly sessions. This allowed each teacher and each child to try out each activity.

The small-group activities focused on the specific cognitive processes of seriation, classification, number, measurement, space, time, and representation. Table 1 gives the number of small-group activities done in each process area. A card catalog of over 200 small-group activities was devised over the two-year period. (Samples of small-group activity cards are included in Appendix A.) Teachers formatively evaluated children's responses to various activities in terms of the four areas of knowledge. Teachers also learned from the small-group time to understand and to be more aware of the children's thinking processes throughout the day.

To follow an activity as it was written was not the most important factor.

It was more important for the group to be together enjoying what they were doing than for them to do the activity exactly as assigned for that day. Because the teachers were aware of the theoretical framework they could use the written activity as an idea or starting point or they could abandon the activity and turn other activities into similar learning situations. Very often the time was used by the groups in very individual ways, such as going for walks and classifying findings, getting the snacks ready, and reading a favorite book a chapter per day.

Outside. The outside area was a modified adventure playground suited to the needs of young children. "Junk" materials such as old tires, boards, crates, ropes, rocks, cable spools, boxes, and blankets were gathered by teachers for children to use in constructing their own climbing equipment, enclosures, and buildings. This facilitated the child's use of his/her own ideas since she/he was involved in a total process rather than in just the end product provided by a typical playground. Mental and physical involvement were also encouraged because teachers had not already molded the idea of a type of play for a specific piece of equipment. The natural elements of sand, water, fire, and mud were important aspects of the playground. One of the most popular areas was a digging hole with boards lining the edges and bridging the mud, which children could stand on while they were digging. Other materials that particularly lent themselves to a variety of uses were a microscope, hammers, nails and boards, cable spools, and hammocks. Children were able to classify items by using

TABLE 1

SUMMARY OF PPEP SMALL-GROUP ACTIVITIES BY PROCESS: WAVE 1 AND WAVE 2

	Wave 1 (P_1)		Wave 2 (P_2)	
	Year 1	Year 2	Year 1	Year 2
Classification	52	45	38	33
Seriation	24	17	21	7
Number	7	18	11	15
Space-Time	25	17	37	26
Measurement	0	5	0	6
Representation	4	3	12	14
Total	112	105	119	101

the microscope; with the construction materials, they used spatio-temporal reasoning in building "houses" for themselves. A "house" for two or three children was different from a "house" for one child, and teachers were alert to pick up on opportunities to query children about these differences. Construction of enclosures also provided many opportunities for planning, problem solving, and predicting outcomes.

For further information on the implications of the theoretical principles for daily classroom activities, see Bingham-Newman, 1974.

Formative evaluation. Formative evaluation was a continuous component of PPEP, and it was done in a variety of ways. Anecdotal records were kept by teachers during the day and after the children left. Small pads of paper and pencils were placed in strategic places around the rooms to aid the teachers in remembering pertinent facts. Parents were kept informed of weekly plans and activities and were encouraged to provide anecdotes from experiences outside of school. Each day one of the teachers spent two hours observing particular children or activities in an effort to increase observational skills and provide feedback on teacher-child interactions. Approximately one hour of daily discussion was held by the team of teachers each day after the children had left to share that day's experiences and observations. In these discussions, activities were evaluated in terms of the materials used, the children's and the teachers' responses, and how closely the activities adhered to the theoretical framework.

At various points each year, records were made (in the manner of the British infant schools) of which children participated in which activities. This aided teachers in evaluating individual children. Finally, evaluations were made daily of small-group activities. Teachers filled out a card for the activity done with the children in their groups and indicated what each child's response to that activity was in terms of several broad goals for the particular process

area used. (See Appendix A for an example.) These evaluations were filed with the activity card itself and were utilized in planning future activities and in evaluating a specific child's level of development. Activities that were particularly enjoyable for children and teachers were often reused with modifications in materials or provisions for use of additional processes.

CONVENTIONAL NURSERY SCHOOL PROGRAM

The control subjects for this study attended a conventional nursery school program (CNSP). Although it used many of the same activities as the PPEP, the way they were used and the reason for using them were rather different. The most significant difference was that the CNSP did not utilize a Piagetian theoretical framework but rather used an eclectic approach that could not be attributed to a particular theory. This meant that teachers planned activities, responded to children, and evaluated children's responses from a different perspective. The aims and goals of the CNSP were primarily concerned with social and physical development. While PPEP stressed underlying cognitive processes, the CNSP teachers focused on performance skills and concepts that were thought necessary for future school experience, e.g., numbers, letters, colors, shapes, opposites. Children were expected to learn through play about the world around them, to work with others, to communicate meaningfully, and to think of school as a pleasant place. Greater physical competence, companionship with peers, increased independence, inner control, and self-confidence were other goals.

The classroom was arranged in the same interest areas as the PPEP; the areas included art, music, dramatic play, nature, large motor, and small manipulative activities. While a new art activity was planned daily, the other areas were not changed as often as in the PPEP. Teachers in the CNSP were more likely to plan activities for either good socioemotional growth or intellectual skill building than to view the two as interdependent. Opportunities for self-expression and sensory experience were other reasons for planning particular activities. For instance, block building was included because children like blocks, can pretend with them, and can move them around easily, while in the PPEP they were also used because they are excellent materials for classification, seriation, and spatial reasoning. In the CNSP, teachers set limits and determined when subject matter, activities, and equipment were introduced and available. The theoretical basis used in the PPEP added depth and a clearer perspective to teachers' understanding of the value of the activities for young children.

The daily schedule followed by the CNSP was very similar to that used in the PPEP; however, the CNSP did not have a small-group time. Here again, while the schedule was the same on the surface, interpretations of procedures differed. Large-group times in the CNSP were viewed as an opportunity for teachers to focus on concept learning or for story telling. During the free play period, teachers in the CNSP assumed more of an authority role in the classroom than PPEP teachers, and children often looked to teachers for help or for answers instead of working autonomously. The teacher's role included

facilitating children's interactions, providing materials, helping solve problems, and setting limits. Teachers were also ready to correct children's wrong answers or misconceptions. Interactions between children were facilitated by teachers so that they would occur with as little conflict as possible. While teachers were not as actively involved in the children's activities as in the PPEP, they did make use of incidental learning in terms of the skills and concepts they wanted children to learn. When teachers were not solving conflicts or helping children in a custodial way, they usually were observing children's play or preparing materials rather than becoming involved in the spontaneous activities.

Snack time was used for relaxing and socializing. It was an opportunity for the children to taste foods they were not used to eating. Clean-up time was used to produce order and to give the children a sense of responsibility for their surroundings. The outside was viewed as a place for large motor skill development in climbing, running, digging, etc.

Most planning was done by the head teacher. Sometimes a unit theme was used; at other times activities were planned in a less structured fashion or to meet the needs of a particular child. Formative evaluation was general and intuitive. Teachers did not spend any appreciable time discussing children's responses or progress. Summative evaluation was not a part of the regular ongoing program and was done only for children included in the present study.

THE TEACHER EDUCATION PROGRAM FOR PPEP

The researchers feel that the Piagetian curriculum framework is only as good as the teachers who implement it. It requires teachers knowledgeable in Piagetian theory and in the implications of the theory for working with preschool children. The comprehensive teacher education program that was developed in conjunction with the curriculum framework involved summer workshops, seminars on Piagetian theory, and practical work with the program. Knowledge and skills in four areas are considered necessary for a teacher to be able to function optimally in a Piagetian classroom. These areas are (1) knowledge of Piagetian developmental theory, (2) skills in observing children's behavior and making useful inferences, (3) knowledge and skill in planning appropriate activities for children, and (4) interaction skills. Within the scope of this paper it is impossible to completely delineate these four areas of knowledge and skills. The following outline indicates in a general manner the content of these areas:

I. Knowledge of Piagetian developmental theory

   A. Goals

      1. Know general principles of development.
      2. Know sequence of stages.
      3. Know characteristics of stage-related abilities in processes of classification, seriation, space, time, number, and representation.

4. Know implications of the theory for teaching.

   a. conceptual differences between the terms theory, method, and techniques
   b. activities and physical environment
   c. teacher role behavior
   d. peer interaction

B. Means of attaining goals

1. Readings
2. Discussion
3. Films
4. Lectures and demonstrations
5. Workshops

II. Skills in observation and inference

A. Goals

1. Develop habits of hypothesis testing.
2. Distinguish between observation and inference.
3. Focus on those elements of a child's behavior that have relevance to Piagetian theory.
4. Act on the basis of accurate observation and inference.

B. Means of attaining goals

1. Observation assignments in natural setting
2. Discussion of observations
3. Observation "games"--mystery boxes, still life, inference board, "following directions," drawing
4. Observation of video tapes to get conflicting inferences
5. Observation of films, with and without sound

III. Knowledge and skills in planning appropriate activities for children

A. Goals

1. Describe activities and teacher behaviors that would enhance or extend a child's development (based on previous observation).
2. Know possible sequences of activities in accordance with the theory.
3. Foresee learning potentials in any given activity.
4. Spontaneously implement curriculum--plan, adjust, or innovate on-the-spot a planned activity to suit needs of the situation and the child (implies quick analysis of the child's abilities and emotions in terms of theory and appropriate planning).

B. Means of attaining goals

1. Observation assignments in natural setting
2. Discussion of observations
3. Planning based on observations
4. Active participation by student teachers in curriculum-specific equipment centers
5. Video tapes
6. Films
7. Practical classroom experience using self-devised plans and plans of other persons

IV. Interaction skills (verbal and nonverbal)

A. Goals

1. Recognize and use open-ended, thought-provoking questions and answers.
2. Recognize personal values and intellectual honesty, and accept and encourage the same in children.
3. Provide cognitive conflict within limits of "the match" (Hunt, 1961).
4. Provide a verbal model for critical thinking (problem-solving approach).
5. Stimulate children to interact with peers through arrangement of environment, materials used, schedule of daily activities, and teacher behaviors.
6. Be a co-worker with the child in solving problems.
7. Design an environment that stimulates children's maximum involvement.
8. Maintain an appropriate social and psychological atmosphere by working with a knowledge of group dynamics.

B. Means of attaining goals

1. Observation of head teacher
2. Discussion
3. Readings
4. Practical experiences with a supervisor
5. Viewing video tapes of self for evaluation
6. Workshops in values, perception and awareness, improvisational drama, and communication skills

The end product of this teacher training course should be a teacher who can integrate theoretical knowledge, skills of observation and analysis, skills of planning, and interaction techniques to provide meaningful experiences for preschool children. These experiences should meet their immediate developmental needs and provide for their future growth and development.

The teacher education program is more thoroughly described and discussed in Saunders (1976, in preparation).

IV

METHODS AND PROCEDURES

EXPERIMENTAL DESIGN

This research integrated aspects of cross-sectional and longitudinal designs involving pretesting and posttesting of two overlapping waves of experimental and control group populations over a period of three years. The first wave of subjects participated in the research from September 1971 through May 1973, while the second wave participated from September 1972 through May 1974. The subjects were pretested when they entered the program at approximately age three and posttested at approximately age five at the conclusion of the two-year period.

SUBJECTS

Eighty children were recruited in two waves for this research. Experimental and control groups in each wave were made up of equal numbers of males and females. The experimental group children were selected randomly from the applications of three-year-olds for admission to the University of Wisconsin-Madison Early Childhood Study Center. The control group children were drawn from a conventional preschool in the nearby community; the control school had an established reputation as a very good conventional nursery school with a well trained staff. Both preschools receive applications from the same population of families. Both groups of children were from professional middle to upper middle-class backgrounds and approximately one-half were from graduate student families. Although the control group was exclusively white, the experimental group was racially mixed.

Sample attrition in both groups generally occurred for three reasons: some children needed day care, some families moved out of town, and a few older subjects went to kindergarten. The final sample size for subjects who remained for the two-year period was 48 children--18 boys and 12 girls in the experimental group and 10 boys and 8 girls in the control group. It is this group of children, henceforth referred to as the core group, with which this research summary is primarily concerned. Descriptive information on the subject sample can be found in Tables 2 and 3.

TABLE 2

DESCRIPTION OF EXPERIMENTAL AND CONTROL GROUPS BY AGE AND SEX

	Wave 1											
	P_1						C_1					
	Boys		Girls		Total		Boys		Girls		Total	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Mean age (months)	41.00	59.00	39.25	57.25	40.41	58.41	42.25	60.25	41.25	59.25	41.75	59.75
Range	35-47	53-65	36-42	54-60	35-47	53-65	37-49	55-67	35-48	53-66	35-49	53-67
SD	4.69		2.75		4.10		4.99		6.25		5.26	

	Wave 2											
	P_2						C_2					
	Boys		Girls		Total		Boys		Girls		Total	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Mean age (months)	41.20	59.20	40.25	58.25	40.78	58.78	38.33	56.33	43.75	61.75	40.50	58.50
Range	38-46	56-64	34-45	52-63	34-46	52-64	36-43	54-61	41-45	59-63	36-45	54-63
SD	2.74		3.57		3.08		2.50		1.89		3.54	

TABLE 3

SUMMARY OF ATTRITION ACROSS DURATION OF THREE-YEAR PROJECT

	Wave 1				Wave 2			
	P_1		C_1		P_2		C_2	
Year	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
1971	10	10	10	10				
1972					11	11	9	9
1973	8	4	4	4				
1974					10	8	6	4

TREATMENT

The experimental subjects participated in the Piagetian Preschool Education Program (PPEP) described in Chapter III four days per week for 2.5 hours per day, while the control subjects attended the conventional preschool five days per week for 2.5 hours per day. Both programs followed the university calendar for holidays and vacations. The teacher-child ratio for both programs, including student teachers as well as regular staff, was one to five. All the teachers in the experimental classroom took part in intensive courses in Piagetian theory and its application to the classroom concurrently with their work with the experimental children. For a more extensive discussion of the teacher education program, see Saunders (1976, in preparation) and Burke-Merkle, Saunders, and Hooper (1973). The typical daily schedule for both classrooms included active and quiet play, individual and group activities, teacher-initiated and child-initiated activities, snacks, and outside play. Major differences between the Piagetian program and the conventional nursery school program existed in (1) the use of an explicit theoretical base, (2) the guidelines for the child's role in the classroom, (3) the guidelines for teacher behaviors, and (4) the use of planning and evaluation (see Chapter III).

TESTERS

Testers were chosen on the basis of their previous experience and their ability to establish rapport and work with young children. Each tester spent approximately 40 hours becoming familiar with the testing procedures and attended at least four group meetings to discuss testing requirements, approach, schedules, equipment, and specific task procedures. Before the actual testing was begun, each tester received extensive practice in administering the tasks to both young

children and adults and in recording responses. Video tapes of testing sessions with children other than the core group members were used to familiarize testers with possible problems. Each tester was trained to administer all tasks and each worked with both experimental and control subjects.[2]

Because of the testing procedure's semi-clinical orientation, care was taken to see that the testers understood the purpose of each task so that they could add or delete words, as appropriate, for each individual child without invalidating the results. During the initial training, each tester became familiar with evaluation guidelines suggested by Kamii (1971). Since testers changed for each of the three years of the project, tester training was repeated yearly. For each testing period there were five testers.

In order to become familiar with the children and to help children become familiar with them, testers spent at least three days in each classroom before administering any tasks. During these days, the testers and children read stories, played games, and explored the testing rooms together. As a result, the children appeared to be quite at ease in the testing situation and usually talked very freely. When testing was begun, the tester a child seemed most responsive to on that day was usually assigned to test that child. A child was not taken to a testing room unless she/he indicated a readiness to go with a tester. Testers were encouraged to make each child as comfortable as possible.

Throughout the year testers met regularly with the researchers. The consensus of teachers, researchers, testers, and parents was that the children, who often requested extra turns, greatly enjoyed the sessions.

EVALUATION MEASURES AND SCORING

The evaluation of the Piagetian-derived program emphasized the assessment of developmental changes in children's thought processes. Included in the evaluation was the assessment of the within-stage growth of the children, the flexibility and applicability of their thinking, and the quantitative and qualitative changes in their thinking across the major developmental stages.

In selecting tasks to use in evaluating the effectiveness of the experimental program, both ethical and conventional research questions were of concern. Ethically, it was necessary to make each testing situation a confortable and interesting experience for the child. This necessitated limiting the amount of testing per child, providing tasks and materials that were appealing to young children, and taking time to establish good tester-child rapport.

Of specific import to this research were (1) assessing cognitive abilities using both Piagetian and non-Piagetian measures, (2) assessing children's thought processes rather than merely accumulating

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[2] Due to the nature of the present research, in which experimental and control subjects were in different locations, it was not possible to use "blind" testers who were unaware of the experimental condition of the subjects.

pass/fail data, (3) assessing the effects of age, sex, and ability level as defined by performances on the Peabody Picture Vocabulary Test and the Raven Coloured Progressive Matrices Test, (4) assessing the effects of a Piagetian-derived program on these aspects of development, and (5) assessing interrelationships between specific cognitive domains.

Based on these considerations, the following measures were selected for the summative evaluation:

1. The Peabody Picture Vocabulary Test (PPVT)

2. The Raven Coloured Progressive Matrices Test (Raven CPM), (Raven, 1956)

3. Classification--dichotomous sorting task (adapted from Kamii, 1971, and Kamii & Peper, 1969)

4. Cross classification matrix (MacKay et al., 1970)

5. Class inclusion task (based on Brainerd & Kaszor, 1974 and Kofsky, 1966)

6. Five seriation tasks (adapted from Burke, 1971)

7. Transitivity task (Brainerd, 1973b)

8. Double seriation matrix (MacKay et al., 1970)

9. Five measurement tasks (adapted from Wohlwill et al., 1971)

10. Three conservation tasks--number (Rothenberg, 1969), length (adapted from Brainerd, 1973b), and substance (modified from Brainerd & Brainerd, 1972, conservation of weight task)

11. Kagan's Matching Familiar Figures Test (MFF) (Kagan, Moss, & Sigel, 1963) and Walk-a-Line/Draw-a-Line Test (Maccoby, Dawley, Kagan, & Degerman, 1965)[3]

[3] Two measures of cognitive style, Kagan's Matching Familiar Figures Test and Walk-a-Line/Draw-a-Line Test of impulse control, were initially included in the testing battery to determine the influence of the impulsivity-reflectivity dimension on subjects' problem-solving abilities. Since a variety of analyses indicated a notable absence of statistically significant relationships in the results, these tests were dropped from the battery and replaced with items of more pertinent interest to the research.

The order of administration of all tasks was randomized across subjects. Testing was conducted in eight 15-minute sessions over a period of six weeks for both the pretest and the posttest. The tasks were given in a game-like atmosphere in a room separate from the classroom. Each child received a task on approximately every third school day over the testing period. (See Appendix B for descriptions of materials used, administration procedures, and scoring procedures for each task.)

SCORING

The two standardized measures, the Raven CPM and the PPVT, were given to characterize the experimental and control samples in terms of normative nonverbal and verbal intelligence, respectively. The Raven CPM, devised in 1947, has been widely used with subjects of all ages from 6 to over 75 years to assess the capacity for intellectual activity relatively independent of previously acquired knowledge. In it, the subject is asked to complete a matrix design with one of six choices shown below the test display. No verbalization is required of the subjects, and little is needed to explain the task.

Pilot work showed that children as young as three years old were able to understand the instructions. For the preschoolers in this study, the administration was altered slightly so that testing was stopped after a child made three successive errors. It has been our experience that children become restless and inattentive when they find themselves very uncertain of their answers. Each child's correct and incorrect responses were recorded so that comparisons of the number of correct responses and an error analysis could be made. Furthermore, several researchers (Flavell & Wohlwill, 1969, among others) have indicated that the Raven CPM is an appropriate measure of multiple classification ability.

The PPVT was used as a counterpart of the Raven CPM. It is a standardized measure of verbal comprehension (receptive understanding) for young children in which children are asked to point to the one of four pictures that represents the word given by the experimenter. The standard administration and scoring procedures for this test are given in the manual for the Peabody Picture Vocabulary Test (Dunn, 1959).

The scoring procedure for the Piagetian tasks was determined by the interest in both qualitative and quantitative change. The stage designations that were used are similar to those used for the original Piagetian experiments. For each task, a child who demonstrated no ability to perform a task was in Stage I. A child who was able to perform a task correctly was in Stage III. Stage II was used to designate a child who was clearly in transition at the time the task was administered. For some tasks, different levels of transitional thinking were indicated by IIc, IIb, and IIa. For instance, a child who demonstrated the correct manipulations of the materials (process) while giving an incorrect response received more credit (Stage IIb) than a child who gave a correct response but manipulated the materials inappropriately throughout the task (Stage IIa). (See Appendix B for a complete description of the stages employed.)

Classification Task Series

Dichotomous sorting. The dichotomous sorting task was used to assess the flexibility of thought involved in the ability to sort consistently on a self-chosen criterion and in the ability to change to a new criterion with the same materials. It was adapted from evaluations developed by Kamii (1971) and Kamii and Peper (1969) for use in the Ypsilanti Preschool Project. The task used in the present study involved a free sort of 22 blocks followed by three dichotomous sorting tasks in which subjects were asked to sort the same blocks into two boxes. (See Appendix B for a description of materials and task administration procedure.) Three dichotomous sorts were possible on the basis of size, shape, and color. Subjects were given a state score of III, IIb, IIa, or I.

Cross classification. A cross classification matrix taken from MacKay et al. (1970) was used to assess the presence of early concrete operational abilities. This is a matrix of blocks sorted into rows by shape (triangles, squares, and cricles) and into columns by color (yellow, red, and blue). After a warm-up consisting of simple replacement of one, two, and finally three blocks (along the matrix "diagonal"), the child is asked to reproduce the original matrix after all blocks have been removed. An additional task involves reconstructing the matrix after the blocks have been removed (reproduction) and one corner block has been replaced so as to rotate the matrix 90 degrees (transposition).

In both instances (simple reproduction and 90 degrees rotation), the purpose is to assess the child's ability to classify on two criteria simultaneously rather than to test accuracy of memory. For this reason matrices were considered correct if whole rows were switched. The stage designations given for reproduction and transposition were III, IIb, IIa, and I.

Class inclusion. A class inclusion task was given as a further test of concrete operational ability. It was based on measures used by Brainerd and Kaszor (1974) and Kofsky (1966). The class inclusion task assesses the child's ability to use the complementary processes of joining subclasses to form a superordinate class (A + A') and dividing superordinate classes into constituent parts (B - A'). The subject must realize that combination and division are opposite processes before he is able to make quantitative comparisons of subclasses and larger groups. In the present study, the subject was presented with six male paper dolls and three female paper dolls. After counting the figures, the subject was queried as to whether there were the same number of boys as children, whether there were more boys than children, and whether there were more children than boys. The order of the three questions was randomly varied across all subjects. A brief warm-up (involving paper representations of cookies and the relational terms more and same) was given to each child before he was presented with the paper dolls. The stage designations for the class inclusion task were III, II, and I.

Seriation Task Series

Unidimensional seriation. The seriation tasks were based on protocols and recommended changes discussed by Burke (1971). These protocols

were originally based on the work of Coxford (1964), Elkind (1964), and Whiteman (1964). They were included to assess developing abilities in ordering objects on a given dimension, in this case, size. This is an important aspect of operational number abilities. The tasks included in this battery and the range of possible responses by stages were as follows:

1. Absolute seriation. Comparison between two sizes. Stages III, II, and I.

2. Relative seriation. Identification of an object as bigger than another object yet smaller than a third. Stages III, IIb, IIa, and I.

3. Successive seriation. Application of relative comparisons in a systematic fashion to a number of objects presented simultaneously. Stages III, IIc, IIb, IIa, and I.

4. Additive seriation. Arrangement of objects in sequence and appropriate insertion of more objects into the original sequence. Stages III, IIb, IIa, and I.

5. Seria. correspondence. Construction of one-to-one correspondence between two sequences of objects. Question 1--Stages III, IIc, IIb, IIa, and I; questions 3 and 4 (combined)--Stages III, IIb, IIa, and I. Question 2 was omitted from the analysis.

Transitivity. The transitivity task was adapted from Brainerd 1973b. It concerned the flexibility of the child's reasoning abilities in the area of transitivity of length. The child was asked to respond to a problem of transitive reasoning; for example, if stick A is longer than stick B, and stick B is equal to stick C, then what is the relationship of stick A to stick C? This task also was used as a correlate indication of seriation, measurement, and conservation abilities. The state designations for this task were III, IIc, IIb, IIa, and I.

Double seriation. A double seriation matrix based on the work of MacKay et al. (1970) was used to assess the subject's ability to coordinate simultaneous change on two dimensions. It required the simultaneous ordering of wooden cylinders on a matrix board according to two dimensions, height and width. After a warm-up consisting of the simple replacement of one, two, and three cylinders, the subjects were asked to reproduce the original matrix after the tester had removed all the cylinders from the board (reproduction) and to reconstruct the original matrix after all the cylinders had been removed and one had been replaced directly opposite its original position, as if the board had been rotated 90 degrees (transposition). Stage designations were recorded separately for reproduction--III, IIb, IIa, and I--and for transposition--III, IIb, IIa, and I.

Measurement Task Series

Spontaneous measurement. These tasks were based on procedures described by Wohlwill et al. (1971). Five tasks were used to reveal the extent to which the child would engage in activities that served a measuring function and that were indicators of developing conservation abilities. The task and the possible stage designations for each were:

1. Length comparison. Identification of the longer object. Stages III, IIb, IIa, and I.

2. Distance via reference length. Equating of two distances using a separate single unit. Stages III, IIb, IIa, and I.

3. Distance via units. Equating of two distances with four equal sized units (quantity). Stages III, IIc, IIb, IIa, and I.

4. Height via reference length. Equating of height of different objects by using an item different from the objects themselves. Stages III, IIb, IIa, and I.

5. Area via units. Comparison of figures divided into unequal numbers of equal sized units. Stages III, IIb, IIa, and I.

Conservation Task Series

Conservation of number. The conservation of number task was taken from Rothenberg's (1969) adaptation of Piaget's original format. This task was included to assess the convergence of seriation and classification abilities in the form of operational number abilities. Two parallel rows of chips were spaced equally in the center of the table, making precise perceptual correspondence. One row was then manipulated by the tester to make it look perceptually different (by collapsing it) although in fact, the two rows were still equal in number of chips. The child was asked whether the rows had equal numbers of chips, whether one row had more, and whether one row had less.

Conservation of length. The conservation of length task, taken from Brainerd and Brainerd (1972), consisted of the changing by the experimenter of the configuration of one of two equal lengths of string. The child was then asked whether the two strings were of equal length, whether one was longer, and whether one was shorter.

Conservation of substance. In the conservation of substance task, adapted from Brainerd and Brainerd (1972), the experimenter deformed one of two balls of equal amounts of clay into a "pancake" shape. He then asked the subject whether the two pieces had the same amount of clay, whether one had more, and whether one had less.

Each conservation task involved three parts. The first was the prediction of what the relation between the two rows, amounts, or lengths would be if the conditions were changed. In the second part, the relation questions were posed in the face of actual transformations.

In the third part, justifications of the responses to the questions about the actual transformations were requested. Stage III responses were recorded with R for a relevant justification or I for an irrelevant justification so that analyses could be carried out both with and without the justification response.

The summative testing schedule is given in Table 4, and a descriptive summary of the complete task battery is given in Tables 5, 6, 7, and 8.

MODES OF ANALYSIS[4]

Due to an emphasis on qualitative data, longitudinal assessment, and associated sample attrition, certain constraints were placed on the statistical analyses. Discrete categorical data for the Piagetian task battery necessitated the use of a nonparametric statistic. Goodman and Kruskal (1954, 1959, 1963) suggested the use of the gamma statistic for ordered data as a measure of the degree of association between multiple variables. Wohlwill (1973b) and L. Hubert (personal communication, 1973 and 1974) also found this measure pertinent to developmental data of this nature.

Using the gamma statistic intra-individual and inter-individual analyses across Time 1 (pretest) and Time 2 (posttest) were carried out. A "change score" analysis as suggested by Wohlwill (1973b) and Wohlwill et al. (1971) was included to ascertain developmental interrelationships between levels of response on one task at Time 1 and another task at Time 2. This technique is aimed at revealing the direction of causal linkages.

Examinations of sampling bias and sex differences at the beginning of each wave were made. Cross-sectional analyses of the experimental and control subjects' pretest responses were carried out to determine subsequent comparability.

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[4] It should be noted by the reader that the analyses reported in the interim progress report (Burke-Merkle, Saunders, & Hooper, 1973) were not used in the present report. It was decided that the use of parametric statistics was inappropriate for these data, and all previous analyses were discarded. Therefore, a comparison should not be attempted between data discussed in the interim report and data discussed in the present report.

TABLE 4

SUMMATIVE TESTING SCHEDULE*

Group (Time of Intake)	Testing Instrument Used					
	Fall 1971	Spring 1972	Fall 1972	Spring 1973	Fall 1973	Spring 1974
Wave 1 Fall 1971						
P_1	PPVT Measurement Classification Seriation		Raven	PPVT Raven Measurement Classification Seriation Transitivity Conservation		
C_1	Cognitive Style 1. Kagan MFF 2. WAL/DAL					
Wave 2 Fall 1972						
P_2			PPVT Raven Measurement Classification Seriation Transitivity Conservation			PPVT Raven Measurement Classification Seriation Transitivity Conservation
C_2						

*Specific time intervals are given in Tables 5, 6, 7, and 8.

TABLE 5

DESCRIPTIVE SUMMARY OF COMPLETE TEST BATTERY: PRETEST ADMINISTERED TO WAVE 1, 1971-72

Test	Theoretical Range	Average Admin. Time	Dates of Administration		Range		Mean		Tester's Subjective Impression
			P_1	C_1	P_1	C_1	P_1	C_1	
PPVT	1-150	15 min.	11/22/71-11/30/71	12/11/71-1/17/72	12-51	38-59	40	48.13	OK
Raven CPM	1-36	15 min.	9/25/72-10/16/72	9/26/72-10/20/72	10-19	10-15	14.83	11.88	OK
Class Inclusion	III-Has concept II-Transition I-No concept		Not administered	Not administered					
Cross Classification	III-Has concept IIb-Transition IIa-Transition I-No concept		Not administered	Not administered					
Seriation	III-Seriates IIc-Transition IIb-Transition IIa-Transition I-No concept		12/1/71-12/16/71	1/11/72-1/27/72	III I-IIa-IIb				OK
Double Seriation	III-Has concept IIc-Transition IIb-Transition IIa-Transition I-No concept		Not administered	Not administered					

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TABLE 5 (cont.)

Test	Theoretical Range	Average Admin. Time	Dates of Administration P_1	Dates of Administration C_1	Range P_1	Range C_1	Mean P_1	Mean C_1	Tester's Subjective Impression
Transitivity	III-Has concept IIc-Transition IIb-Transition IIa-Transition I-No concept		Not administered	Not administered					
Measurement	III-Measures IIc-Transition IIb-Transition IIa-Transition I-No concept		11/29/71-12/8/71	11/6/72-1/18/72	III I-IIa- IIb	III I-IIa- IIb			Fun
Conservation	III-Conserves II-Transition I-No concept		Not administered	Not administered					
Dichotomous Sorting	III-Classifies IIb-Transition IIa-Transition I-No concept	15 min.	2/10/72-3/7/72	3/1/72-3/13/72	I-IIa	IIa- IIb- III			OK

TABLE 6

DESCRIPTIVE SUMMARY OF COMPLETE TEST BATTERY: POSTTEST ADMINISTERED TO WAVE 1, 1973

Test	Theoretical Range	Average Admin. Time	Dates of Administration		Range		Mean		Tester's Subjective Impression
			P_1	C_1	P_1	C_1	P_1	C_1	
PPVT	1-150	10 min.	2/13/73-2/19/73	2/19/73-3/2/73	44-62	46-63	53.16	55.87	OK
Raven CPM	1-36	9 min.	2/14/73-2/20/73	2/21/73-3/8/73	8-16	12-22	13.83	14.37	OK
Class Inclusion	III-Has concept II-Transition I-No concept	3 min.	2/28/73-3/20/73	3/5/73-3/28/73					Fun
Cross Classification	III-Has concept IIb-Transition IIa-Transition I-No concept	6 min.	2/28/73-3/20/73	3/5/73-3/28/73					Fun
Seriation	III-Seriates IIc-Transition IIb-Transition IIa-Transition I-No concept	12 min.	3/5/73-3/15/73	3/5/73-3/27/73					Frustrating for student and examiner
Double Seriation	III-Has concept IIc-Transition IIb-Transition IIa-Transition I-No concept	7 min.	3/6/73-3/20/73	3/6/73-3/28/73					Fun

TABLE 6 (cont.)

Test	Theoretical Range	Average Admin. Time	Dates of Administration P_1	Dates of Administration C_1	Range P_1	Range C_1	Mean P_1	Mean C_1	Tester's Subjective Impression
Transitivity	III-Has concept IIc-Transition IIb-Transition IIa-Transition I-No concept	3 min.	3/6/73-3/20/73	3/6/73-3/28/73					OK
Measurement	III-Measures IIc-Transition IIb-Transition IIa-Transition I-No concept	6 min.	2/19/73-3/20/73	2/26/73-3/29/73					OK
Conservation	III-Conserves II-Transition I-No concept	10 min.	2/21/73-3/1/73 3/12/73-3/20/73	3/2/73-3/29/73					Frustrating at times
Dichotomous Sorting	III-Classifies IIb-Transition IIa-Transition I-No concept	12 min.	2/22/73-3/19/73	2/26/73-3/27/73					OK

TABLE 7

DESCRIPTIVE SUMMARY OF COMPLETE TEST BATTERY: PRETEST ADMINISTERED TO WAVE 2, 1972

Test	Theoretical Range	Average Admin. Time	Dates of Administration		Range		Mean		Tester's Subjective Impression
			P_2	C_2	P_2	C_2	P_2	C_2	
PPVT	1-150 1-150	15 min.	9/20/73-10/22/72	9/22/72-10/26/72	12-68	20-56	40.44	44.10	OK
Raven CPM	1-36 1-36	15 min.	9/25/72-10/24/72	9/29/72-11/2/72	4-16	4-14	10.28	9.60	Long and tedious; frustrating for children and examiner
Class Inclusion	III-Has concept II-Transition I-No concept	3 min.	10/18/72-12/3/72	10/23/72-11/20/72	I-II-III	I-II-III			Fun for children
Cross Classification	III-Has concept IIb-Transition IIa-Transition I-No concept	5 min.	10/18/72-12/5/72	10/23/72-11/20/72	III I-IIa-IIb	I-IIb-III			Fun for children; blocks enjoyed
Seriation	III-Seriates IIc-Transition IIb-Transition IIa-Transition I-No concept	12 min.	10/17/72-12/6/72	10/2/72-11/20/72	III I-IIa-IIb	IIc-III I-IIa-IIb			Frustrating for children and examiner
Double Seriation	III-Has concept IIc-Transition IIb-Transition IIa-Transition I-No concept	5 min.	10/31/72-12/6/72	11/2/72-11/29/72	I-IIa-IIb	III I-IIa-IIb			Fun for both examiner and children

TABLE 7 (cont.)

Test	Theoretical Range	Average Admin. Time	Dates of Administration P_2	Dates of Administration C_2	Range P_2	Range C_2	Mean P_2	Mean C_2	Tester's Subjective Impression
Transitivity	III-Has concept IIc-Transition IIb-Transition IIa-Transition I-No concept	3 min.	10/3/72-12/6/72	11/2/72-11/29/72	III I-IIa -IIc	IIc-III I-IIa- IIb			OK
Measurement	III-Measures IIc-Transition IIb-Transition IIa-Transition I-No concept	8 min.	10/3/72-12/4/72	10/4/72-12/4/72	III I-IIa- IIb	IIc-III I-IIa- IIb			Fun
Conservation	III-Conserves II-Transition I-No concept	11 min.	11/6/72-1/22/73	11/7/72-11/29/72	I-II- III	I-II- III			Hard to hold attention
Dichotomous Sorting	III-Classifies IIb-Transition IIa-Transition I-No concept	15 min.	10/10/72-12/5/72	10/19/72-11/17/72	I-IIa	I-IIa- IIb			Confusing at times

TABLE 8

DESCRIPTIVE SUMMARY OF COMPLETE TEST BATTERY: POSTTEST ADMINISTERED TO WAVE 2, 1974

Test	Theoretical Range	Average Admin. Time	Dates of Administration P_2	Dates of Administration C_2	Range P_2	Range C_2	Mean P_2	Mean C_2	Tester's Subjective Impression
PPVT	0-150 0-150	9 min.	3/5/74-3/13/74	3/4/74-4/8/74	46-70	46-68	54.44	58.70	OK
Raven CPM	1-36	8 min.	3/12/74-3/22/74	3/7/74-4/8/74	8-20	12-19	13.00	15.80	Posttest-OK, enjoyed giving to older children
Class Inclusion	III-Has concept II-Transition I-No concept	3 min.	3/20/74-4/11/74	3/14/74-3/21/74	I-II	I-II			Varied media kept interest, but some questions were confusing
Cross Classification	III-Has concept IIb-Transition IIa-Transition I-No concept	5 min.	3/20/74-4/11/74	3/14/74-3/21/74	III I-IIa- IIb	III I-IIa IIb			Children enjoyed blocks
Seriation	III-Seriates IIc-Transition IIb-Transition IIa-Transition I-No concept	11 min.	3/19/74-4/11/74	3/7/74-4/17/74	IIc- III I-IIa- IIb	IIc- III IIa- IIb			Blocks unique; Most children kept interest. OK
Double Seriation	III-Has concept IIc-Transition IIb-Transition IIa-Transition I-No concept	6 min.	3/21/74-4/11/74	3/7/74-4/17/74	III I-IIa- IIb	III I-IIa- IIb			Blocks unique; enjoyable because children liked it. Fun.

TABLE 8 (cont.)

Test	Theoretical Range	Average Admin. Time	Dates of Administration P_2	Dates of Administration C_2	Range P_2	Range C_2	Mean P_2	Mean C_2	Tester's Subjective Impression
Transitivity	III-Has concept IIc-Transition IIb-Transition IIa-Transition I-No concept	3 min.	3/21/74-4/11/74	3/7/74-4/17/74	I-IIc-III	I-III			OK
Measurement	III-Measures IIc-Transition IIb-Transition IIa-Transition I-No concept	6 min.	3/4/74-4/11/74	3/7/74-4/22/74	IIc-III I-IIa-IIb	I-IIa-III			Interesting for children, attention held by varied media. OK
Conservation	III-Conserves II-Transition I-No concept	10 min.	3/15/74-4/23/74	3/8/74-4/9/74	I-II-III	III I-II			Some questions hard for children to understand; liked play dough the best
Dichotomous Sorting	III-Classified IIb-Transition IIa-Transition I-No concept	12 min.	3/14/74-4/11/74	3/12/74-4/18/74	IIb I-IIa	III IIa-IIb			Fun and imaginative; children enjoyed for the most part. OK

V

RESULTS AND DISCUSSION

It was hypothesized that the children who participated in the Piagetian Preschool Education Program (PPEP) would, as a by-product of their experience, exhibit overall higher levels of responses on various Piagetian tasks than the children in the control group, who participated in a conventional nursery school program (CNSP). Furthermore, it was hypothesized that all the subjects, because they were within the age range suggested for the preoperational period, would show a relatively high degree of structural mix in their response patterns on both the pretest and posttest. Finally, it was hypothesized that the subjects would indicate a greater degree of developmental convergence within a concept domain than across concept domains.

PRELIMINARY CONSIDERATIONS

The first major analysis dealt with whether the experimental children and the control children could be considered equivalent prior to their participation in the preschool programs. Independent *t*-tests were carried out on the age variable and on the pretest scores for the standardized non-Piagetian measures, the PPVT and Raven CPM. The *t*-tests indicated that there were no significant differences on the age variable or on the PPVT scores. The *t*-test for the Raven CPM pretest scores revealed that for Wave 1, the experimental group performed significantly better than the control group ($t = 2.4840$, df 16, $p < .05$).

A comparison was made of the continuing longitudinal sample participants to the children who withdrew from the programs prior to completion of two years. This was done in order to establish whether subsequent differences between the groups were due to differential sample attrition. Independent *t*-tests indicated no significant differences on the age variable, PPVT, or Raven CPM pretest scores (see Table 9). This is in contrast to expected sample attrition effects and is surprising in view of typical longitudinal research findings (see Riegel, Riegel, & Meyer, 1967, and Riegel & Riegel, 1972).

PRIMARY CONSIDERATIONS

Normative Analyses

For the Piagetian tasks, normative data indicating typical age-performance patterns were established by determining the percentages

TABLE 9

COMPARISON OF CONTINUING LONGITUDINAL SAMPLE (CORE) TO DROPOUTS ON AGE AND TWO STANDARDIZED MEASURES: PRETEST SCORES

	Wave 1				Wave 2			
	P_1		C_1		P_2		C_2	
	Core	Drop-outs	Core	Drop-outs	Core	Drop-outs	Core	Drop-outs
Age								
N	12	8	8	12	18	4	10	7
Mean	40.41	38.87	41.75	43.83	40.78	40.25	40.50	42.43
SD	4.10	2.29	5.26	4.78	3.08	3.30	3.54	1.81
t*	.9622		.9178		.3066		1.32	
df	18		18		20		15	
PPVT								
N	12	8	8	12	18	4	10	7
Mean	40.00	33.50	48.13	46.42	40.44	40.00	44.10	53.71
SD	10.85	13.26	7.75	8.27	12.51	9.13	11.48	8.24
t*	1.20		.4634		.0666		1.89	
df	18		18		20		15	
Raven CPM								
N	12	6**	Not given		18	4	10	7
Mean	14.83	13.17			10.28	13.25	9.60	9.57
SD	2.98	1.94			2.85	3.77	3.50	4.16
t*	1.2353				1.7905		.0153	
df	14				20		15	

*All t values are non-significant.

**Because the Raven CPM was given at the beginning of the second year, it was not given to children who had left the previous spring. Thus two dropouts in P_1 and all dropouts in C_1 did not take this test.

of all subjects' responses, control and experimental groups combined, in each stage response category for each subtask on the pretest and on the posttest. The subjects were approximately three years old at the time of the pretest and approximately five years old at the time of the posttest. (See Appendix C for the complete raw score responses by stage designations for each experimental and control group.) The percentages indicate an overall increase in subjects' responses in the higher response categories on the posttest. Unequal percentages of subjects at Stage III across all subtasks indicate differing degrees of difficulty within the task battery. On the three measurement subtasks--distance via reference length, distance via units, and area via units--and on the double seriation, transposition subtask, a notably lower percentage of subjects were at the higher stage categories on the posttest (see Tables 10, 11, 12, and 13).

Normative data for the standardized measures, the PPVT and the Raven CPM, for the total group of subjects (N = 48) indicate that higher scores were more evident on the posttest. This would be anticipated from normal developmental change over a two-year period. The fact that the lower limits of the ranges of scores for both tests moved up on the posttest while the upper limits stayed approximately the same (see Table 14) is unusual. A possible explanation is that the unusually high scores on the pretest were caused by measurement error.

Cross-Sectional Analyses

Cross-sectional analyses compared the performances of the experimental and control group subjects in each wave on the pretest and on the posttest. These analyses were carried out using the nonparametric gamma statistic (Goodman & Kruskal, 1954, 1959, 1963).[5] It is essential for the reader to realize that gamma is a measure of association that indicates whether it is probable that untied responses would be in the same category on two ordered variables. When responses are in different categories for the two variables, the sign of the gamma value indicates which variable has responses in a higher category. The significance level for gamma indicates how likely it would be for that pattern to occur by chance alone and takes into consideration the marginal totals, not just the untied cases. For this reason, there can be two gamma values that are equal in strength but only one that is associated with a significant prediction.

[5] The reader should note that a gamma value of ± 1 is often indicative of inflation due to zero cell frequencies in the data. Since gamma deals only with untied pairs, the value becomes distorted more easily with a small sample. The gamma values of ± 1 that are due to this type of distortion are labeled as such in the text.

TABLE 10

PERCENTAGES OF ALL CHILDREN (N = 48) AT VARIOUS STAGES ON SERIATION, DOUBLE SERIATION, AND TRANSITIVITY TASKS--PRETEST AND POSTTEST

			Percent at Stage				
Task	Subtask	Test	I	IIa	IIb	IIc	III
Seriation	Absolute	Pre	16	4	*	*	79
		Post	0	12	*	*	87
	Relative	Pre	20	56	14	*	8
		Post	37	33	22	*	6
	Successive	Pre	58	18	20	2	0
		Post	10	10	12	8	58
	Additive	Pre	.45	29	18	*	6
		Post	2	27	14	*	56
	Serial Correspondence 1	Pre**	25	25	21	7	18
		Post	4	10	25	4	56
	Serial Correspondence 3 & 4	Pre	35	14	45	*	4
		Post	6	18	60	*	14
Double Seriation	Reproduction	Pre	92	3	0	*	3
		Post	25	16	4	*	54
	Transposition	Pre	85	10	3	*	0
		Post	41	14	33	*	10
Transitivity	--	Pre	42	14	3	25	14
		Post	16	0	0	10	72

*This division of Stage II was not used for this subtask.
**N = 28. The pretest was not administered to P_1 or C_1. There was one no-response.

TABLE 11

PERCENTAGES OF ALL CHILDREN (N = 48) AT VARIOUS STAGES ON DICHOTOMOUS SORTING, CLASS INCLUSION, AND CROSS CLASSIFICATION TESTS--PRETEST AND POSTTEST

			Percent at Stage			
Task	Subtask	Test	I	IIa	IIb	III
Dichotomous Sorting	--	Pre	43	50	6	0
		Post	2	31	39	27
Class Inclusion	--	Pre*	64	25	**	10
		Post	62	31	**	6
Cross Classification	Reproduction	Pre*	53	32	10	3
		Post	4	50	6	39
	Transposition	Pre*	67	12	10	0
		Post	20	37	18	22

*N = 28. P_1 and C_1 groups were not given this task on the pretest.
**Stage II was not divided for this task. Stage II responses are listed in the IIa column.

TABLE 12

PERCENTAGES OF ALL CHILDREN (N = 48) AT VARIOUS STAGES ON THE MEASUREMENT TASK--PRETEST AND POSTTEST

			Percent at Stage				
Task	Subtask	Test	I	IIa	IIb	IIc	III
Measurement	Length Comparison	Pre	64	8	4	*	22
		Post	12	8	2	*	77
	Distance via Reference Length	Pre	95	4	0	*	0
		Post	77	12	6	*	4
	Distance via Units	Pre	91	6	2	0	0
		Post	64	18	10	0	6
	Height via Reference Length	Pre	18	20	2	*	58
		Post	0	2	4	*	93
	Area via Units	Pre	75	14	6	*	4
		Post	54	20	6	*	18

*This division of Stage II was not used for this subtask.

TABLE 13

PERCENTAGES OF ALL CHILDREN AT VARIOUS STAGES ON THE CONSERVATION TASKS--PRETEST (N = 28) AND POSTTEST (N = 48)

			Percent at Stage		
Task	Subtask	Test	I	II	III
Conservation of Number	Prediction	Pre	85	7	7
		Post	52	18	29
	Deformation	Pre	78	21	0
		Post	68	4	27
Conservation of Length	Prediction	Pre	75	25	0
		Post	64	14	20
	Deformation	Pre	75	25	0
		Post	77	8	14
Conservation of Substance	Prediction	Pre	78	17	3
		Post	58	10	31
	Deformation	Pre	85	3	10
		Post	64	6	29

TABLE 14

PRETEST AND POSTTEST NORMATIVE DATA: MEANS, RANGES, AND STANDARD DEVIATIONS ON STANDARDIZED NON-PIAGETIAN MEASURES FOR ALL CORE GROUP SUBJECTS

Task	Test	Mean	Range	SD
PPVT	Pre	42.37	12-68	11.17
	Post	55.25	40-68	6.83
Raven CPM	Pre	11.54	4-19	3.44
	Post	14.02	8-20	3.05

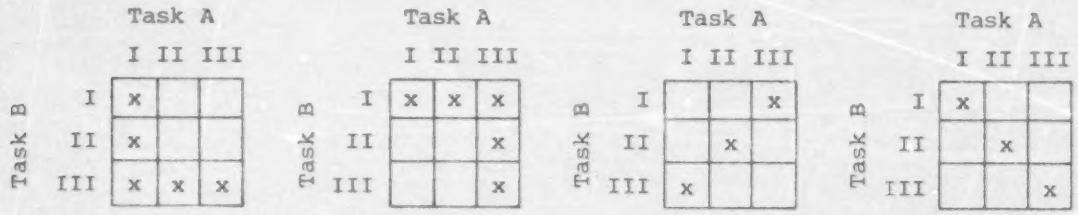
TABLE 15

SUMMARY OF GAMMA VALUES FOR THE CROSS-SECTIONAL ANALYSES--PRETEST AND POSTTEST: WAVE 1, $P_1 \times C_1$, AND WAVE 2, $P_2 \times C_2$

	Pretest				Posttest			
	Wave 1 $P_1 \times C_1$		Wave 2 $P_2 \times C_2$		Wave 1 $P_1 \times C_1$		Wave 2 $P_2 \times C_2$	
	γ Val.	Sign. Level	γ Val.	Sign. Level	γ Val.	Sign. Level	γ Val.	Sign. Level
Dichotomous Sorting	.75	$p<.05$	.65	$p<.05$	.21	ns	.75	$p<.01$
Class Inclusion	Not given		-.16	ns	.35	ns	.33	ns
Cross Classification, Reproduction	Not given		.33	ns	-.59	$p<.05$	.43	ns
Cross Classification, Transposition	Not given		.11	ns	-.13	ns	-.43	ns
Seriation								
Absolute	1.	ns	-.24	ns	-.22	ns	1	$p<.05$
Relative	.35	ns	.44	ns	.23	ns	.64	$p<.01$
Successive	-.15	ns	.12	ns	.30	ns	.48	$p<.05$
Additive	-.34	ns	.15	ns	-.10	ns	.73	$p<.01$
Serial Correspondence 1	Not given		0	ns	.22	ns	.32	ns
Serial Correspondence 3 & 4	.19	ns	.28	ns	.33	ns	.25	ns
Double Seriation, Reproduction	Not given		1.0	$p<.05$	.09	ns	-.07	ns
Double Seriation, Transposition	Not given		.36	ns	-.03	ns	-.29	ns
Transitivity	Not given		.5	$p<.05$	.51	ns	.62	ns
Measurement								
Length Comparison	-.50	ns	-.11	ns	-.55	ns	0	ns
Distance via Reference Length	-1	ns	1.	ns	.52	ns	.27	ns
Distance via Units	-1	ns	1.	ns	.09	ns	.21	ns
Height via Reference Length	.25	ns	.04	ns	*		1	ns
Area via Units	-.52	ns	.83	$p<.01$	-.04	ns	.35	ns
Conservation								
Number, Prediction	Not given		.77	$p<.05$	-.44	ns	0	ns
Number, Deformation	Not given		-.07	ns	-.14	ns	.30	ns
Number, Adjusted	Not given		*		-.06	ns	.63	ns
Length, Prediction	Not given		-.21	ns	-.18	ns	-.04	ns
Length, Deformation	Not given		-.21	ns	.13	ns	.09	ns
Length, Adjusted	Not given		*		.13	ns	.30	ns
Substance, Prediction	Not given		.30	ns	-.19	ns	.22	ns
Substance, Deformation	Not given		-.26	ns	.04	ns	.30	ns
Substance, Adjusted	Not given		*		-.11	ns	.37	ns

*All subjects in both groups were in Stage I.

Table 15 indicates that there are very few significant differences between the Wave 1 experimental and control group subjects on the Piagetian measures. Using a gamma value of .48 as a cutoff point, it is possible to indicate a number of interesting cases. Gamma values higher than .48 could be expected to show a fairly consistent pattern approaching the patternings of responses shown below in which the gamma values would be $\pm$ 1.



For Wave 1 pretest scores on the measurement subtasks, the experimental group performed better on length comparison (γ = .50), distance via reference length (γ = -1), distance via units (γ = -1), and area via units (γ = -.50), but these differences were not significant. Wave 1 posttest comparisons indicate that the control group did better on transitivity (γ = .51) and distance via reference length (γ = .52) but, again, such differences could occur by chance alone. The experimental group maintained its pretest lead on length comparison (γ = -.55). For Wave 2, the control group did significantly better on the pretest for double seriation, reproduction (γ = 1.0, p < .05), transitivity (γ = .5, p < .05), area via units (γ = .83, p < .01), and conservation of number, prediction (γ = .77, p < .05). On the posttest, the control group maintained its lead on transitivity (γ = .62), but the difference is no longer significant. In addition, the control group was significantly better on absolute seriation (γ = 1.0, p < .05), relative seriation (γ = .64, p < .01), successive seriation (γ = 1.0, p < .05), and additive seriation (γ = .73, p < .01) and nonsignificantly better on conservation of number, deformation-adjusted (γ = .63).

Comparisons of experimental and control groups on the classification measures show no significant differences in performance on either the class inclusion or cross classification, transposition, tasks. Both control groups, however, performed significantly better than the experimental groups on the pretest for dichotomous sorting (Wave 1, γ = .75, p < .05; Wave 2, γ = .65, p < .05. The degree of difference was not maintained on the posttest. The difference between groups remained significant for Wave 2 (γ= .75, p < .01) but was nonsignificant for Wave 1 (γ = .21). Except for the posttest comparison in Wave 1, there were no significant comparisons between groups for the cross classification, reproduction, task. The first wave was not pretested on this task, but posttests showed a higher general performance level for the control group (γ = -.59, p < .05).

It is difficult to determine whether the greater improvement by the experimental groups on the dichotomous sorting task can be attributed to a program effect. Classification abilities certainly were a major concern of the PPEP, and a variety of activities involving choosing criteria and making sorts were used in the program. The initial performance differences, however, prevent the assertion of a distinct cause-effect relationship.

The percentages of Wave 1 and Wave 2 subjects in each stage on each task on the pretest and posttest are presented in Tables 16 through 23. For both experimental and control groups, the percentage of subjects in Stage III was considerably smaller for relative seriation than for the other seriation tasks at pretesting and posttesting. Examination of the protocol for this task (see Appendix B) suggests that the language used by the tester may have been confusing. Siegel (1974) goes so far as to state that the verbal nature of the typical Piagetian measures may be a principal source of performance variance (perhaps leading to asynchrony) and that an exact determination of the young child's abilities awaits the development of more sophisticated and appropriate nonverbal techniques. Language may present a communication barrier to adequate assessment of a young child's thought. Such difficulties may well have had a bearing on the results on other Piagetian measures utilized in this research.

TABLE 16

PERCENTAGES OF CHILDREN AT VARIOUS STAGES ON THE THREE CLASSIFICATION TASKS--PRETEST AND POSTTEST: WAVE 1, EXPERIMENTAL (N = 12) AND CONTROL (N = 8) GROUPS

				Percent at Stage			
Task	Subtask	Group	Test	I	IIa	IIb	III
Dichotomous Sorting	--	P_1	Pre	50	50	0	0
			Post	0	25	33	41
		C_1	Pre	12	87	0	0
			Post	0	12	37	50
Class Inclusion	--	P_1	Pre				
			Post	75	8	*	16
		C_1	Pre				
			Post	50	37	*	12
Cross Classification	Reproduction	P_1	Pre				
			Post	8	16	8	67
		C_1	Pre	0			
			Post	0	75	0	25
	Transposition	P_1	Pre				
			Post	25	16	8	50
		C_1	Pre				
			Post	0	37	50	12

*Stage II was not divided for this task. Stage II responses are listed in the IIa column.

TABLE 17

PERCENTAGES OF CHILDREN AT VARIOUS STAGES ON THE SERIATION, DOUBLE SERIATION, AND TRANSITIVITY TASKS--PRETEST AND POSTTEST: WAVE 1, EXPERIMENTAL (N = 12) AND CONTROL (N = 8) GROUPS

				Percent at Stage				
Task	Subtask	Group	Test	I	IIa	IIb	IIc	III
Seriation	Absolute	P_1	Pre	8	*	0	*	91
			Post	0	*	8	*	91
		C_1	Pre	0	*	0	*	100
			Post	0	*	12	*	87
	Relative	P_1	Pre	8	75	8	*	8
			Post	50	16	33	*	0
		C_1	Pre	0	75	12	*	12
			Post	62	25	0	*	12
	Successive	P_1	Pre	58	16	25	0	0
			Post	8	16	8	0	66
		C_1	Pre	62	25	12	0	0
			Post	0	0	25	0	75
	Additive	P_1	Pre	33	25	33	*	8
			Post	0	8	16	*	75
		C_1	Pre	50	37	0	*	12
			Post	0	16	0	*	75
	Serial Correspondence 1	P_1	Pre	Not administered				
			Post	16	8	8	0	66
		C_1	Pre	Not administered				
			Post	0	25	0	0	75
	Serial Correspondence 3 & 4	P_1	Pre	58	16	25	*	0
			Post	8	25	50	*	16
		C_1	Pre	50	12	37	*	0
			Post	0	0	100	*	0
Double Seriation	Reproduction	P_1	Pre	Not administered				
			Post	25	8	0	*	66
		C_1	Pre	Not administered				
			Post	0	37	0	*	62
	Transposition	P_1	Pre	Not administered				
			Post	33	8	41	*	16
		C_1	Pre	Not administered				
			Post	37	0	50	*	12
Transitivity	--	P_1	Pre	Not administered				
			Post	25	0	0	8	66
		C_1	Pre	Not administered				
			Post	12	0	0	0	87

*This division was not used for this subtask.

TABLE 18

PERCENTAGES OF CHILDREN AT VARIOUS STAGES
ON THE MEASUREMENT TASKS--PRETEST AND POSTTEST:
WAVE 1, EXPERIMENTAL (N = 12) AND CONTROL (N = 8) GROUPS

				Percent at Stage				
Task	Subtask	Group	Test	I	IIa	IIb	IIc	III
Measurement	Length Comparison	P_1	Pre	41	0	8	*	50
			Post	0	16	0	*	83
		C_1	Pre	62	12	12	*	12
			Post	25	12	0	*	62
	Distance via Reference Length	P_1	Pre	91	8	0	*	0
			Post	83	16	0	*	0
		C_1	Pre	100	0	0	*	0
			Post	62	25	12	*	0
	Distance via Units	P_1	Pre	75	25	0	0	0
			Post	50	25	16	0	8
		C_1	Pre	100	0	0	0	0
			Post	50	12	25	0	12
	Height via Reference Length	P_1	Pre	25	16	0	*	58
			Post	0	0	0	*	100
		C_1	Pre	25	0	0	*	75
			Post	0	0	0	*	100
	Area via Units	P_1	Pre	58	33	0	*	8
			Post	41	25	0	*	33
		C_1	Pre	87	0	0	*	12
			Post	37	25	25	*	12

*This division was not used for this subtask.

TABLE 19

PERCENTAGES OF CHILDREN AT VARIOUS STAGES
ON THE CONSERVATION TASKS--POSTTEST*:
WAVE 1, EXPERIMENTAL (N = 12) AND CONTROL (N = 8) GROUPS

				Percent at Stage		
Task	Subtask	Group	Test	I	II	III
Conservation of Number	Prediction	P_1	Post	50	8	41
		C_1	Post	75	0	25
	Deformation	P_1	Post	66	8	25
		C_1	Post	75	0	25
Conservation of Length	Prediction	P_1	Post	66	16	16
		C_1	Post	75	12	12
	Deformation	P_1	Post	75	0	25
		C_1	Post	62	25	12
Conservation of Substance	Prediction	P_1	Post	41	25	33
		C_1	Post	62	0	37
	Deformation	P_1	Post	58	16	25
		C_1	Post	62	0	37

*No conservation pretest was administered to these children.

TABLE 20

PERCENTAGES OF CHILDREN AT VARIOUS STAGES ON THE THREE CLASSIFICATION TASKS--PRETEST AND POSTTEST: WAVE 2, EXPERIMENTAL (N = 18) AND CONTROL (N = 10) GROUPS

				Percent at Stage				
Task	Subtask	Group	Test	I	IIa	IIb	IIc	III
Dichotomous Sorting	--	P_2	Pre	61	38	0	*	0
	--		Post	5	50	44	*	0
		C_2	Pre	30	40	30	*	0
			Post	0	20	40	*	40
Class Inclusion	--	P_2	Pre	61	27	*	*	11
			Post	66	33	*	*	0
		C_2	Pre	70	20	*	*	10
			Post	50	50	*	*	0
Cross Classification	Reproduction	P_2	Pre	61	27	5	*	5
			Post	5	61	11	*	22
		C_2	Pre	40	40	20	*	0
			Post	0	50	0	*	50
	Transposition	P_2	Pre	72	11	16	*	0
			Post	22	38	16	*	22
		C_2	Pre	60	40	0	*	0
			Post	30	60	10	*	0
Double Seriation	Reproduction	P_2	Pre	100	0	0	*	0
			Post	33	11	5	*	50
		C_2	Pre	80	10	0	*	10
			Post	30	20	10	*	40
	Transposition	P_2	Pre	88	11	0	*	0
			Post	38	27	22	*	11
		C_2	Pre	80	10	10	*	0
			Post	60	10	30	*	0
Transitivity	--	P_2	Pre	55	11	0	27	5
			Post	16	0	0	22	61
		C_2	Pre	20	20	10	20	30
			Post	10	0	0	0	90

*Stage II was not divided for this task.

TABLE 21

PERCENTAGES OF CHILDREN AT VARIOUS STAGES ON THE SERIATION, DOUBLE SERIATION, AND TRANSITIVITY TASKS--PRETEST AND POSTTEST: WAVE 2, EXPERIMENTAL (N = 18) AND CONTROL (N = 10) GROUP

				Percent at Stage				
Task	Subtask	Group	Test	I	IIa	IIb	IIc	III
Seriation	Absolute	P_2	Pre	22	*	5	*	72
			Post	0	*	22	*	77
		C_2	Pre	30	*	10	*	60
			Post	0	*	0	*	100
	Relative	P_2	Pre	44	33	16	*	5
			Post	38	38	16	*	5
		C_2	Pre	10	60	20	*	10
			Post	0	50	40	*	10
	Successive	P_2	Pre	61	11	27	0	0
			Post	22	16	11	5	44
		C_2	Pre	50	30	10	10	0
			Post	0	0	10	30	60
	Additive	P_2	Pre	55	22	16	*	5
			Post	5	44	27	*	22
		C_2	Pre	40	40	20	*	0
			Post	0	20	0	*	80
	Serial Correspondence 1	P_2	Pre	27	22	22	11	16
			Post	0	5	50	5	338
		C_2	Pre**	20	30	20	0	20
			Post	0	10	20	10	60
	Serial Correspondence 3 & 4	P_2	Pre	27	16	44	*	11
			Post	11	22	50	*	16
		C_2	Pre	10	10	80	*	0
			Post	0	20	60	*	20
Double Seriation	Reproduction	P_2	Pre	100	0	0	*	0
			Post	33	11	5	*	50
		C_2	Pre	80	10	0	*	10
			Post	30	20	10	*	40
	Transposition	P_2	Pre	88	11	0	*	0
			Post	38	27	22	*	11
		C_2	Pre	80	10	10	*	0
			Post	60	10	30	*	0
Transitivity	--	P_2	Pre	55	11	0	27	5
			Post	16	0	0	22	61
		C_2	Pre	20	20	10	20	30
			Post	10	0	0	0	90

*This division of Stage II was not used for this subtask.

**N = 9; one subject did not respond on the pretest, hence no stage designation could be made.

TABLE 22

PERCENTAGES OF CHILDREN AT VARIOUS STAGES
ON THE MEASUREMENT TASKS--PRETEST AND POSTTEST:
WAVE 2, EXPERIMENTAL (N = 18) AND CONTROL (N = 10) GROUPS

				Percent at Stage				
Task	Subtask	Group	Test	I	IIa	IIb	IIc	III
Measurement	Length Comparison	P_2	Pre	72	16	0	*	11
			Post	11	5	5	*	77
		C_2	Pre	80	0	0	*	20
			Post	20	0	0	*	80
	Distance via Reference Length	P_2	Pre	100	0	0	*	0
			Post	83	0	11	*	5
		C_2	Pre	90	10	0	*	0
			Post	70	20	0	*	10
	Distance via Units	P_2	Pre	100	0	0	0	0
			Post	77	16	5	0	0
		C_2	Pre	90	0	10	0	0
			Post	70	20	0	0	10
	Height via Reference Length	P_2	Pre	22	16	5	*	55
			Post	0	5	11	*	83
		C_2	Pre	0	50	0	*	50
			Post	0	0	0	*	100
	Area via Units	P_2	Pre	94	0	5	*	0
			Post	72	11	5	*	11
		C_2	Pre	50	30	20	*	0
			Post	50	30	0	*	20

*This division of Stage II was not used for this subtask.

TABLE 23

PERCENTAGES OF CHILDREN AT VARIOUS STAGES ON THE CONSERVATION TASKS--PRETEST AND POSTTEST: WAVE 2, EXPERIMENTAL (N = 18) AND CONTROL (N = 10) GROUPS

				Percent at Stage		
Task	Subtask	Group	Test	I	II	III
Conservation of Number	Prediction	P_2	Pre	94	5	0
			Post	44	33	22
		C_2	Pre	70	10	20
			Post	50	20	30
	Deformation	P_2	Pre	77	22	0
			Post	72	5	22
		C_2	Pre	80	20	0
			Post	60	0	40
Conservation of Length	Prediction	P_2	Pre	72	27	0
			Post	61	11	27
		C_2	Pre	80	20	0
			Post	60	20	20
	Deformation	P_2	Pre	72	27	0
			Post	83	5	11
		C_2	Pre	80	20	0
			Post	80	10	10
Conservation of Substance	Prediction	P_2	Pre	83	11	5
			Post	66	11	22
		C_2	Pre	70	30	0
			Post	60	0	40
	Deformation	P_2	Pre	83	5	11
			Post	72	5	22
		C_2	Pre	90	0	10
			Post	60	0	40

For Wave 1, 100 percent of the control group was in the transitional Stage IIb on the posttest for serial correspondence 3 and 4. For the absolute seriation task, 77 percent of the experimental group and 100 percent of the control group in Wave 2 was in Stage III on the posttest. These results probably indicate a ceiling effect for these subtasks.

For the measurement subtasks of distance via reference length and distance via units, there was very little change from pretest to posttest in percentages of experimental and control subjects at each stage. In the conservation battery, the percentages of prediction responses in the higher stage designations do not appear to be appreciably greater than the percentages of deformation responses. For the deformation subtask in most cases there were no subjects in Stage III on the pretest, while by the posttest 22 percent to 40 percent of the subjects were in Stage III. The experimental group responses are generally spread across all the stages on the conservation tasks. The Wave 1 and Wave 2 control groups, however, had no responses in the transitional Stage II on the posttest for any of the conservation tasks except, for both groups, conservation of length prediction and deformation and, for Wave 2, number prediction. The Wave 2 control group responses for conservation of substance on the posttest presented the only instance of the theoretically expected bimodal distribution.

Performances on the classification tasks followed a general pretest to posttest trend out of Stage I and into the higher stages (see Tables 11, 16, and 20). An exception to this trend is the performance of the Wave 2 experimental group on the class inclusion task. Most of the responses remained in Stage I; there was virtually no change from the pretest to the posttest. The control group showed the general trend of movement out of Stage I on this task, although a sizable number (50 percent) remained in Stage I on the posttest. A comparison of responses on this task to those on the dichotomous sorting task suggests that class inclusion abilities develop later, or perhaps slower, than abilities to sort dichotomously. For the groups in general, the percentage of posttest responses in Stage III was much greater for the dichotomous sorting task than for the class inclusion task. Group differences were apparent in the dichotomous sorting task, where the Wave 2 control group performed better than the Wave 2 experimental group (40 percent of the control group in Stage III compared to 0 percent for the experimental group), and in the cross classification, transposition task, where the Wave 2 experimental group had a larger percentage of subjects in Stage III than the control group (22 percent and 0 percent, respectively).

Core group t-test comparisons were carried out on the age variable for the pretest and on the PPVT and Raven CPM scores for the pretest and posttest for each wave (see Table 24). No significant differences were found for age or PPVT. A significant difference was found between the experimental and control groups for the Wave 1 Raven CPM pretest ($t = 2.480$, $df = 18$, $p < .05$) that indicated that the experimental group was superior. However, this difference no longer existed on the posttest Raven CPM comparison. For Wave 2, there was a significant difference on the posttest Raven CPM comparison that indicated that the control group was superior ($t = 2.2212$, $df = 26$, $p < .05$).

TABLE 24

CORE GROUP t-TEST COMPARISONS OF AGE AND STANDARDIZED MEASURES FOR WAVE 1 AND WAVE 2: PRETEST AND POSTTEST

	Wave 1				Wave 2			
	Pretest		Posttest		Pretest		Posttest	
	P_1	C_1	P_1	C_1	P_2	C_2	P_2	C_2
Age								
N	12	8			18	10		
Mean	40.41	41.75			40.78	40.50		
SD	4.10	5.26	Same		3.08	3.54	Same	
t	.64				.22			
df	18							
PPVT								
N	12	8	12	8	18	10	18	10
Mean	40.00	48.13	53.17	55.87	40.44	44.10	54.44	58.70
SD	10.85	7.75	5.72	5.84	12.51	11.48	7.82	6.80
t	1.82		1.03		.76		1.44	
df	18		18					
Raven CPM								
N	12	8	12	8	18	10	18	10
Mean	14.83	11.88	13.83	14.37	10.28	9.60	13.00	15.80
SD	2.98	1.89	2.17	3.34	2.85	3.50	3.63	2.15
t	2.48*		.44		.56		2.22*	
df	18		18					

* $p < .05$.

In short, there were few significant differences between the experimental and control core groups in the two waves of subjects, and almost no differences were maintained from pretesting to posttesting. While the Wave 1 experimental group performed somewhat better on a few tasks on the pretest, with the exception of the length comparison task it failed to retain this lead or establish other leads on the posttest. The control group, while not surpassing the experimental group on any task on the pretest, did perform somewhat better on several tasks on the posttest. The Wave 2 control group performed significantly better than the experimental group on five tasks on the pretest, but with the exception of the dichotomous sorting task it did not retain a significant lead on these tasks on the posttest. The control group did perform significantly better than the experimental group on four of the seriation tasks on the posttest--absolute, relative, successive, and additive seriation. The *t*-test comparisons indicated no significant differences between the groups on age or PPVT. The significant difference between the experimental and control groups on the Raven CPM posttest, in which the control group was superior, is not traceable to a particular cause. However, the greater use of puzzles and games with one correct solution in the CNSP may have contributed to the higher performance of the control group.

In retrospect, it is perhaps not unduly surprising that the first hypothesis concerning overall higher response levels by the experimental group was not supported by the results. The environment in the home and in the community outside of school has a large impact on development. This is particularly true for three- and four-year-olds who spend only 2.5 hours a day in a school program. Both groups of preschool children in this study were drawn from the same population and, therefore, from the same general nonschool environment. It seems likely that the following shared factors are particularly influential on the development of children in this population: SES, community location, family structure, mobility, long- and short-term achievement expectations, and general attitudes toward child rearing. The effects of experiences common to both groups may well have overshadowed any effects of differential schooling. In addition, finer measures may be needed to distinguish between programs when the nonschool environment is already meeting the basic needs for cognitive development.

Sharper distinctions between programs might also have led to differences in performance. Original differences in approach diminished as the study progressed. Most notably, several members of the CNSP became interested in Piagetian theory and could not be denied the opportunity to participate in workshops offered to the public that were run by PPEP personnel. Also, student teachers in both programs had had training in Piagetian theory before their practicum experience so that, particularly in the early weeks of each semester, interactions between student teachers and children were similar in the two programs. Since there were no major differences between the experimental and control groups in either wave, subsequent discussion including that dealing with cross-sectional data will primarily focus on pretest to posttest comparisons.

The marked lack of difference in performance between pretest and posttest on the distance via reference length and the distance via units measurement tasks is supported by the other statistical analyses carried out. These two tasks were particularly difficult for the three- to five-year-old children. This finding is in contrast to that of Wohlwill et al. (1971), who found that for kindergartners and first graders the distance via reference length task and the length comparison task were the easiest of the measurement battery. The present research indicated that height via reference length and length comparison were the two least difficult tasks in the measurement battery. Through personal communication with Wohlwill (1974), it was discovered that the height via reference length task was carried out with somewhat different instructions in the two studies; the instructions used in the present research made this task a height comparison task for many children. In the present research the child was not prohibited from moving the house itself in finding a house of similar size while in the Wohlwill et al. (1971) research she/he was.

The percentages for the conservation tasks, which indicate very little difference between the prediction and deformation responses, are unexpected. Piaget (1952) suggested that conservation develops in three stages: in Stage I the child can neither predict nor conserve (in the deformation part of the task); in Stage II she/he can predict but not conserve; and in Stage III she/he can do both equally well. Thus it was expected that the preoperational child would predict correctly before he would perform the deformation correctly. Piaget (1966) and Bruner, Olver, Greenfield et al. (1966) found that preoperational subjects could correctly predict the empirical outcome of a transformation. Toniolo and Hooper (1974), in a study of observation of length and weight with young children, however, found no difference between performances on prediction and deformation.

It was also expected that there would be more responses in the transitional Stage II than in Stage III for the conservation tasks, but this was not the case. It may be that not enough children moved out of Stage I during the two-year period for these differences to be evident or that children are in Stage II for such a short time that in the present research some children who moved to Stage III were never assessed as being in Stage II. The fact that the experimental group had a larger percentage of Stage II responses than did the control group on both the prediction and deformation components of the conservation tasks may be a result of the emphasis placed on prediction in problem-solving abilities in the PPEP. This result may also be due to the stress placed by the PPEP on operational integration, which would be expected to facilitate structural transformation.

Longitudinal Analyses

The longitudinal analyses dealt with the gains made by each group from pretesting to posttesting. The results indicate an increased ability in cognitive reasoning and understanding for all groups. Analyses with the gamma statistic compared the pretest to the posttest scores for each experimental and control group. Table 25 presents a summary of

TABLE 25

SUMMARY OF GAMMA VALUES FOR THE LONGITUDINAL ANALYSES: WAVE 1 AND WAVE 2, PRETEST TO POSTTEST COMPARISONS FOR THE EXPERIMENTAL AND CONTROL GROUPS

	Wave 1				Wave 2			
	P_1		C_1		P_2		C_2	
	γ Val.	Sign. Level	γ Val.	Sign. Level	γ Val.	Sign. Level	γ Val.	Sign. Level
Dichotomous Sorting	1.0	$p<.001$		$p<.001$	.94	$p<.001$	.85	$p<.01$
Class Inclusion	Not given				-.19	ns	.27	ns
Cross Classification, Reproduction	Not given				.75	$p<.001$	.75	$p<.01$
Cross Classification, Transposition	Not given				.67	$p<.01$	.59	ns
Seriation								
Absolute	.04	ns	-1.0	ns	.25	ns	1.0	$p<.01$
Relative	-.28	ns	-.73	$p<.01$	.06	ns	.38	ns
Successive	.83	$p<.001$	1.0	$p<.001$	.67	$p<.001$	.98	$p<.00$
Additive	.89	$p<.001$	.92	$p<.01$	.66	$p<.01$	.91	$p<.00$
Serial Correspondence 1	Not given				.56	$p<.01$	.72	$p<.01$
Serial Correspondence 3 & 4	.75	$p<.01$	1.0	$p<.01$	.25	ns	.36	ns
Double Seriation, Reproduction	Not given				1.0	$p<.001$	.74	$p<.01$
Double Seriation, Transposition	Not given				.86	$p<.001$	.46	ns
Transitivity	Not given				.79	$p<.001$	.77	$p<.01$
Measurement								
Length Comparison	.67	$p<.05$	.67	$p<.05$	.90	$p<.001$	.88	$p<.01$
Distance via Reference Length	.38	ns	1.0	$p<.05$	1.0	$p<.05$	.60	ns
Distance via Units	.56	ns	1.0	$p<.01$	1.0	$p<.01$	.51	ns
Height via Reference Length	1.0	$p<.01$	1.0	ns	.63	$p<.01$	1.0	$p<.01$
Area via Units	.40	ns	.67	$p<.05$	.71	$p<.05$	.06	ns
Conservation								
Number, Prediction	Not given				.91	$p<.001$	.33	ns
Number, Deformation	Not given				.25	ns	.54	ns
Number, Adjusted	Not given				1.0	ns	1.0	$p<.05$
Length, Prediction	Not given				.36	ns	.50	ns
Length, Deformation	Not given				-.21	ns	.06	ns
Length, Adjusted	Not given				1.0	ns	1.0	ns
Substance, Predicted	Not given				.44	ns	.38	ns
Substance, Deformation	Not given				.32	ns	.71	ns
Substance, Adjusted	Not given				1.0	ns	1.0	ns

the gamma values for the longitudinal analyses. Gamma values less than .50 are not considered in the following discussion of these results.

On the classsification measures, the Wave 1 experimental group made significant gains on the dichotomous sorting task ($\gamma = 1.0$, $p < .001$). The Wave 2 experimental group also made significant gains on this task ($\gamma = .94$, $p < .001$) as well as on the two cross classification tasks (reproduction: $\gamma = .75$, $p < .001$; transposition: $\gamma = .67$, $p < .01$). Patterns for the control groups were similar to those for the experimental groups except that no statistically significant gains were made by the Wave 2 control group on the cross classification, transposition, task. None of the groups showed much change on the class inclusion task. This is not particularly surprising in view of recent discussions of class inclusion understanding (e.g., Brainerd, 1973, and Brainerd & Kaszor, 1974) that contend that these tasks may indeed involve formal operational reasoning.

An examination of the seriation measures indicates that the Wave 1 experimental group did significantly better on the posttest than on the pretest for successive seriation ($\gamma = .83$, $p < .001$), additive seriation ($\gamma = .87$, $p < .001$), and serial correspondence 3 and 4 ($\gamma = .75$, $p < .01$). The Wave 2 experimental group also made significant gains from the pretest to the posttest on successive seriation ($\gamma = .67$, $p < .001$), additive seriation ($\gamma = .66$, $p < .01$), and serial correspondence 1 ($\gamma = .56$, $p < .01$). It should be noted that serial correspondence 1 is analogous to a successive seriation task (see Appendix B). In addition, the Wave 2 experimental group showed significant gains on double seriation, reproduction ($\gamma = 1.0$, $p < .001$) and transposition ($\gamma = .86$, $p < .001$), and on transitivity ($\gamma = .79$, $p < .001$). The Wave 1 control group showed a significant regression from pretest to posttest on relative seriation ($\gamma = -.73$, $p < .01$). However, they made significant gains on additive seriation ($\gamma = .92$, $p < .01$), successive seriation ($\gamma = 1.0$, $p < .001$), and serial correspondence 3 and 4 ($\gamma = 1.0$, $p < .001$). Table 25 indicates that they also performed worse on absolute seriation ($\gamma = -1.0$); however, because there were so many ties, this gamma value took into account only two responses. The Wave 2 control group made significant gains on absolute seriation ($\gamma = 1.0$, $p < .01$), successive seriation ($\gamma = .98$, $p < .001$), additive seriation ($\gamma = .91$, $p < .001$), and serial correspondence 1 ($\gamma = .72$, $p < .01$). It should be pointed out that the Wave 2 experimental group also made significant gains on the latter three tasks. In addition, like the Wave 2 experimental group, the Wave 2 control group made significant gains on double seriation, reproduction ($\gamma = .74$, $p < .01$) and transitivity ($\gamma = .77$, $p < .01$).

Generally, both waves of experimental and control subjects made significant gains on the seriation subtasks. This is a concept domain in which preoperational subjects typically made gains (see Bingham-Newman & Hooper, 1975 and Burke-Merkel & Hooper, 1973). In addition, the Wave 2 experimental and control groups made significant gains on the more difficult double seriation and transitivity tasks. The differences in gains between Wave 1 and Wave 2 on serial correspondence 1 and serial correspondence 3 and 4 are indicative of a possible cohort and/or program effect. Moreover, the significant gains on the more difficult double seriation, transposition, and cross classification, transposition

tasks for the experimental group only may be indicative of a program effect since the experimental program emphasized the kind of logical reasoning that these tasks require.

The longitudinal analyses of the measurement battery generally indicate gains on the posttest. The Wave 1 experimental group made significant gains on length comparison ($\gamma = .67$, $p < .05$) and height via reference length ($\gamma = 1.0$, $p < .01$) and nonsignificant gains on distance via units ($\gamma = .56$). Like the Wave 1 experimental group, the Wave 2 experimental group made significant gains on length comparison ($\gamma = .90$, $p < .001$). This group also made significant gains on distance via reference length ($\gamma = 1.0$, $p < .05$), distance via units ($\gamma = 1.0$, $p < .01$), height via reference length ($\gamma = .6$, $p < .01$), and area via units ($\gamma = .71$, $p < .05$).

In comparison, the Wave 1 control group made significant gains on length comparison ($\gamma = .67$, $p < .05$), distance via reference length ($\gamma = 1.0$, $p < .05$), distance via units ($\gamma = 1.0$, p [illegible] and area via units ($\gamma = .67$, $p < .05$). Table 25 also indicates that this control group gained on height via reference length ($\gamma = 1.0$); however, because of ties, this gamma value is based on only two responses and is non-significant. Like the Wave 1 control group, the Wave 2 control group made significant gains on length comparison ($\gamma = .88$, $p < .01$). This group also made significant gains on height via reference length ($\gamma = 1.0$, $p < .01$) and nonsignificant gains on distance via reference length ($\gamma = .60$) and distance via units ($\gamma = .51$).

In summary, the gamma values for the longitudinal measurement comparisons indicate that none of the groups performed worse on the posttest than on the pretest. Thus, regression effects would appear to have been negligible. Each of the groups improved on length comparison, height via reference length, and distance via units, and each made significant gains on the length comparison and height via reference length measurement tasks. As was mentioned previously, because of an error in the instructions the height via reference length task could be considered a height comparison task. Thus, it is appropriate that groups that made significant gains on the length comparison task made significant gains on this task. The significant gains on the other, more difficult, measurement tasks are most probably due to some children moving out of Stage I.

Longitudinal analyses of the conservation battery indicated that the Wave 2 experimental group did significantly better on the posttest on the conservation of number, prediction, task ($\gamma = .91$, $p < .001$). Table 25 indicates that there were a number of other cases with gamma over .50 in which the Wave 2 experimental group performed better on the posttest; however, because of the number of ties the gamma value is based on only a few cases. The gamma values indicate that the Wave 2 control group performed significantly better on the posttest on conservation of number, deformation-adjusted ($\gamma = 1.0$, $p < .05$). Furthermore, this group made nonsignificant gains on conservation of number, deformation ($\gamma = .54$), and conservation of substance, deformation ($\gamma = .71$). Other gamma values that appear to indicate superior posttest performance for this group are again due to only a few cases because of ties.

Overall, for the conservation tasks gamma values over .50 show that the groups did better on the posttest than on the pretest.

Although many children remained in Stage I, there was a general increase in the number of children in Stages II and III across the conservation tasks. Interestingly, the Wave 2 experimental group did a great deal better on the posttest on conservation of number, prediction, while the Wave 2 control group did better on conservation of number, deformation, both adjusted and not adjusted. This again may be due to the emphasis on prediction experiences in the PPEP.

While the Piagetian tasks are sensitive to intellectual differences at early ages, it appears that they could be further refined to give more information on what young children do know than on what they don't know. Siegel's (1974) comments on the language components of the tasks are germane to this point. In addition, the use of a more clinical method and of stimuli that are particularly relevant to young children may prove beneficial. For instance, in training testers for the Wave 2 posttesting for the present research, it was found that when scoops of ice cream were used instead of clay balls for the conservation of substance task, several three-year-olds who could not conserve with clay balls could both predict and conserve substance. In the conservation of length task, children queried about whether one string was longer than the other after one was made into a circle invariably said the straight string was longer. From explanations given by the children, it was discerned that they thought the question referred to actual length in space rather than to the string itself. In actual measurement of the space occupied by the strings, the straight one was longer. Miller, Grabowski, and Heldmeyer (1972) cite the salience of the length dimension for preschoolers in the conservation of substance task.

Table 26 presents the t-test results for pretest to posttest changes on the standardized measures, PPVT and Raven CPM, for each wave. The comparisons indicate that significant gains were made by all groups on the PPVT. However, only the Wave 2 experimental and control groups performed significantly better on the Raven CPM posttest. This is more likely a reflection of the shorter time between the Raven CPM pretest and posttest for Wave 1 than an indication of cohort differences. The 4.5-month interval may not have been long enough for age-related changes measurable with this task to occur--at least for this age range.

The Wave 1 experimental group made significant gains on the PPVT ($t = 4.27$, $df = 11$, $p < .001$) but not, as mentioned above, on the Raven CPM. The Wave 1 control group likewise performed significantly better on the PPVT posttest ($t = 3.23$, $df = 7$, $p < .05$) but made no significant gain on the Raven CPM. Although neither trend was significant, the mean score on the Raven CPM increased in the control group and decreased in the experimental group.

The Wave 2 experimental group performed significantly better on the PPVT posttest ($t = 6.13$, $df = 17$, $p < .001$) and on the Raven CPM posttest ($t = 2.87$, $df = 17$, $p < .05$). The Wave 2 control group also performed significantly better on the PPVT posttest ($t = 3.33$, $df = 9$, $p < .01$) and on the Raven CPM posttest ($t = 4.06$, $df = 9$, $p < .01$). The similarities here suggest that measurement errors rather than program differences may have resulted in the directions of change noted on the Raven CPM performances for Wave 1.

TABLE 26

COMPARISON OF PRETEST TO POSTTEST CHANGES ON STANDARDIZED MEASURES FOR EXPERIMENTAL AND CONTROL GROUPS: WAVE 1 and WAVE 2

	Wave 1				Wave 2			
	P_1		C_1		P_2		C_2	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
PPVT								
N	12	12	8	8	18	18	10	10
Mean	40.00	53.17	48.13	55.87	40.44	54.44	44.10	58.70
SD	10.85	5.72	7.75	5.84	12.51	7.82	11.48	6.80
t	4.27***		3.23*		6.13***		3.33**	
df	11		7		17		9	
Raven CPM								
N	12	12	8	8	18	18	10	10
Mean	14.83	13.83	11.88	14.37	10.28	13.00	9.60	15.80
SD	2.98	2.17	1.89	3.34	2.85	3.63	3.50	2.15
t	1.43		1.49		2.87*		4.06**	
df	11		7		17		9	

* $p \leq .05$
** $p \leq .01$
*** $p \leq .001$

Percentages of several different types of pretest to posttest changes in stage on each task summed over all tasks for Wave 1 are presented in Figure 1. Similar information for Wave 2 is shown in Figure 2. The experimental and control groups follow a strikingly similar pattern, with the highest percentage of responses for each wave remaining in the transitional Stage II. Moreover, the figures indicate that the majority of all responses in each wave remained in the same stage. Most of the changes for each wave followed the stage sequence determined prior to scoring; approximately one-tenth of the responses indicated a change in the reverse direction. This small amount could be expected from normal statistical regression effects or measurement error. Not only were the experimental and control groups almost identical, but the two waves of subjects also followed the same pattern.

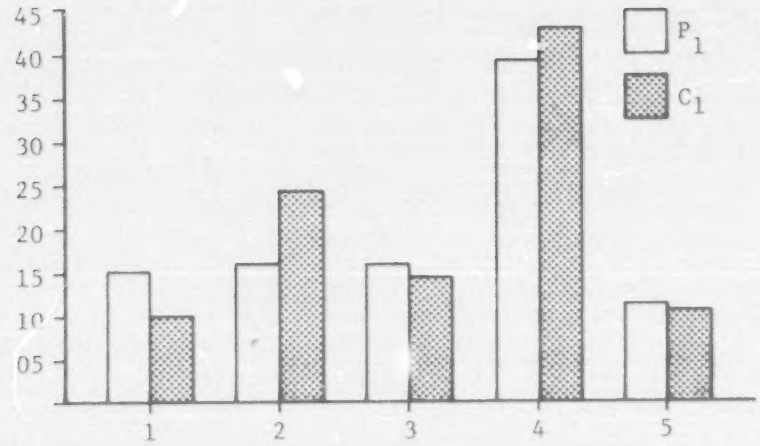
Subjects who remained in the same stage or substage (category 4, Figures 1 and 2) gave primarily transitional Stage II responses. This again may be because of the relatively short period between measurement times (approximately 15 months) and the very young age of the subjects at the beginning of the research. A 15-month period with five- to seven-year-olds would probably have resulted in considerably different outcomes. During the period from three to five years, reorganization of operational structures may not have progressed enough to be apparent.

In addition, Kamii and DeVries (1974) suggest that Piagetian theory is even more relevant to the socioemotional area of development than to the cognitive area of development. It may be that the present Piagetian measures, while assessing the framework of operational abilities essential in any interactions with objects, people, or events, do not tap the socioemotional aspects of development with which young children are struggling. Although Piaget emphasizes the integral aspects of socioemotional growth with cognitive growth, the present tasks do not appear to evaluate the degree of integration.

Moreover, it is likely that the period between measurements in this research was shorter than the time required for transformation of cognitive structures through equilibrium mechanisms and the processes of simple and reflective abstraction necessary for the construction of physical and logico-mathematical knowledge. Differences between the experimental and control groups, notably absent from the present results, might have shown up in later measurements. Also, the PPEP attempted to optimize and extend the use of structures already present rather than to accelerate the functional and structural changes that occur developmentally, and it is possible that the concrete operational tasks did not measure the degree of extension.

Another reason for many responses remaining in Stage II could be the phenomenon of spiral development suggested by Werner (1957), in which an individual is expected to move ahead and then back again before moving further ahead developmentally. If this is the case, it would be profitable to retest children at shorter intervals. However, attention would need to be given to establishing controls that would allow for measurement of the test-retest effects.

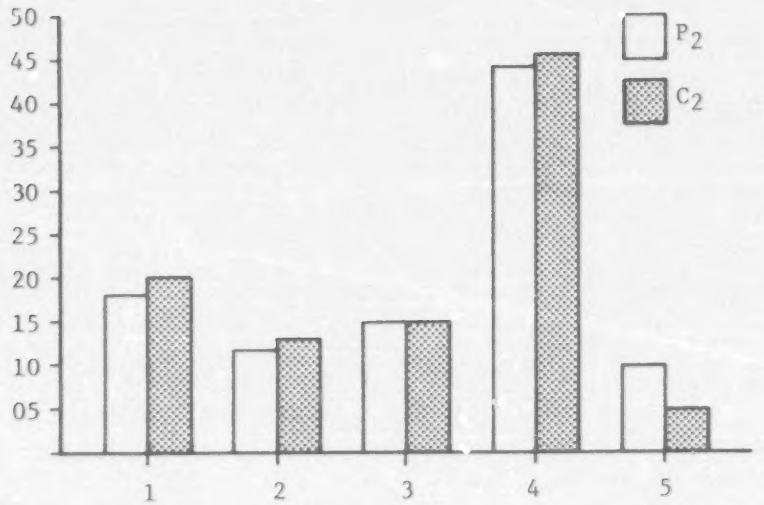
Wohlwill (1968) points out that the variables that are effective in concrete situations change. Although the operational ability may



Change from pretest to posttest on any single task

1. Followed stage sequence in order (no skips).
2. Followed stage sequence with skips on substages.
3. Went from Stage I to Stage III.
4. Remained in same stage or substage.
5. Reversed order of stages.

Figure 1. Percentages of pretest to posttest changes in stage on each task summed over all tasks: Wave 1.



Changes from pretest to posttest on any single task

1. Followed stage sequence in order (no skips).
2. Followed stage sequence with skips on substages.
3. Went from Stage I to Stage III.
4. Remained in same stage or substage.
5. Reversed order of stages.

Figure 2. Percentages of pretest to posttest changes in stage on each task summed over all tasks: Wave 2.

be available, the situational variables may retard its expression. This could account for the many instances in which spontaneous operational performance witnessed by teachers in the PPEP did not show up in the testing results. However, an observational study of the spontaneous classroom behaviors would be necessary to substantiate what the teachers saw happening. A study comparing the results of typical task assessment and naturalistic observation of the same subject could shed light on Wohlwill's (1970) suggestion that the very young child does not reveal his abilities fully in a testing situation. He suggests that the child often becomes stimulus bound by the directions of the task in an experimental situation and does not solve the problem creatively as he would in a natural situation.

OTHER CONSIDERATIONS[6]

Within-Stage Correspondence Analyses

The data were rearrayed in frequency tables to determine within-stage correspondence of the subjects' performances. Separate analyses were made for the pretest and the posttest. A representative sample of tasks was chosen prior to preparing the frequency tables to examine synchrony within a concept domain as well as across concept domains. In preparing the tables for this analysis, the various Stage II subcategories were collapsed into a single Stage II category. In addition, the Wave 1 and Wave 2 experimental groups were combined for one analysis (Table 27) and the Wave 1 and Wave 2 control groups were combined for another analysis (Table 28).

The almost complete lack of synchrony found in the within-stage correspondence analysis is particularly notable. Typical patterns exhibited by reponses on various pairs of tasks are as follows:

Transitivity

Distance via Reference Length	I	II	III
I	5	5	15
II	1	0	3
III	0	0	1

Double Seriation, Transposition

Transitivity	I	II	III
I	0	1	1
II	0	0	0
III	9	7	0

[6] Matrix analyses and correlational analyses between the classification tasks and the standardized measures are not included here, but can be found in Saunders (1976, in preparation).

TABLE 27

SUMMARY OF SELECTED GAMMA VALUES FOR WITHIN-STAGE CORRESPONDENCE COMPARISONS ON PIAGETIAN TASKS: TOTAL EXPERIMENTAL GROUP, PRETEST AND POSTTEST

	Dichotomous Sorting		Class Inclusion		Cross Classification, Reproduction		Cross Classification, Transposition		Serial Correspondence 3 & 4		Double Seriation, Transposition		Transitivity		Distance Via Reference Length	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Class Inclusion	-.57	-.67														
Cross Classification, Reproduction	.59	.21	-.27	.12												
Cross Classification, Transposition	.54	.72**														
Serial Correspondence 3 & 4	<u>-.54</u>**	.32			.29	.97****										
Double Seriation, Reproduction									—	.65**						
Double Seriation, Transposition	.25	.24			.17	.56**	—	.32	.90	.12						
Transitivity	.07	.30			.32	.77***			-.32	.57	-1.00	.63***				
Distance Via Reference Length	<u>-1.00</u>	.62	—	-.35	—	.1	—	.12	<u>-1.00</u>	-.06	—	.49	—	.34		
Distance Via Units									<u>-.57</u>	.09	—	.05	—	.59**		
Conservation of Number, Prediction	1.00	.30			-1.00	.24			-1.00	.45	-1.00	.05	-1.00	.49**	—	.60**
Conservation of Number, Deformation	.29	.7			-.41	.45			-.14	-.20	-1.00	.07	-1.00**	.79**	—	.69**
Conservation of Length, Prediction	-1.00**	.00			.42	-.03			.33	-.56			.30	.29	—	.00
Conservation of Length, Deformation	-.55	.13			- 56	.12			.33	-.25			-.66	63	—	.00
Conservation of Substance, Prediction	-.04	.58**			-.08	.62**			.86**	.14			-1.00**	78***	—	.51
Conservation of Substance, Deformation	-.09	.68**			-.13	.37			.85	.13			-1.00**	.76**	—	.67***

*Underlined values are for P_1 and P_2. All other values are for P_2 only. A dash indicates a comparison that could not be calculated because all responses on one variable were in Stage I.

**$p < .05$
***$p < .01$
****$p < .001$

TABLE 28

SUMMARY OF SELECTED GAMMA VALUES FOR WITHIN-STAGE CORRESPONDENCE COMPARISONS ON PIAGETIAN TASKS: TOTAL CONTROL GROUP, PRETEST AND POSTTEST

	Dichotomous Sorting		Class Inclusion		Cross Classification, Reproduction		Cross Classification, Transposition		Serial Correspondence 3 & 4		Double Seriation, Transposition		Transitivity		Distance Via Reference Length	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Class Inclusion	-.27	-.09														
Cross Classification, Reproduction	-.20	.93***	-.27	-.64												
Cross Classification, Transposition	.20	-.03														
Serial Correspondence 3 & 4	1.00	-1.00			-1.00	-1.00										
Double Seriation, Reproduction									1.00	-.50						
Double Seriation, Transposition	-1.00***	-.09			1.00	-.29	.25	.94**	1.00	-.05						
Transitivity	.20	-.13			-.75	-.25			-1.00	1.00	-.20	-1.00**				
Distance Via Reference Length	1.00	.62	-1.00	.36	1.00	-.05	-1.00	.50	1.00	.29	-1.00	.64**	-1.00	-.52		
Distance Via Units									1.00	.11	-1.00	.69**	-1.00	-.42		
Conservation of Number, Prediction	1.00	.09			.09	.29			1.00	.37	-1.00	.47	-.13	-.33	1.00**	.90***
Conservation of Number, Deformation	1.00	.17			-.25	.33			-1.00**	.37	-1.00	.63**	1.00**	-.37	-1.00	.96****
Conservation of Length, Prediction	1.00	.07			1.00	.37			-1.00**	.16			-.08	1.00	1.00**	.41
Conservation of Length, Deformation	-.50	.05			1.00	.05			-1.00**	-1.00			.60	-.33	-1.00	.58
Conservation of Substance, Prediction	-.11	-.05			-.67	.14			1.00	.25			.38	-1.00**	-1.00	.92***
Conservation of Substance, Deformation	1.00	-.05			-1.00	.14			1.00	.25			1.00	-1.00**	-1.00	.92***

*Underlined values are for C_1 and C_2. All other values are for C_2 only.

**$p < .05$

***$p < .01$

****$p < .001$

Double Seriation, Reproduction × Serial Correspondence 3 & 4

	I	II	III
I	5	11	3
II	0	0	0
III	0	0	0

Serial Correspondence 3 & 4 × Dichotomous Sorting

	I	II	III
I	4	7	0
II	12	4	0
III	1	1	0

These types of asynchrony suggest what Piaget describes as horizontal décalage, that is, differing levels of achievement involving similar mental operations. While Piaget hypothesized that many similar operations develop in synchrony, he also recognized horizontal décalages as developmental phenomena. It may be that the shifting responses characteristic of the preoperational child resulted in some of the asynchrony findings. The results are supportive of the hypothesis based on the work of Wohlwill (1973b), Flavell (1971), and Turiel (1969) that subjects in the transitional preoperational period would show a relatively high degree of structural mix in their response patterns across a battery of Piagetian tasks. In fact, more mix was evident on the posttest than on the pretest.

The hypothesis that there would be a greater degree of developmental convergence within a concept domain than across concept domains was not supported since the only significant convergence occurred in the pretest; there were many clusters of responses in Stage I for both tasks in the pairwise comparison. Trends from pretest to posttest indicate that the subjects generally moved out of Stage I, and patterns on the posttest showed a wider spread across all stage categories. There were few responses on the posttest that fell into Stage I on both tasks. There were also more similarities in patterns between the control and experimental groups on the posttest than on the pretest.

In sharp contrast to the present results, which show few five-year old children in Stage I, Gonchar (1975), in a cross-sectional study of classes, relations, and numbers, found that kindergarten children clustered mainly in Stage I on similar tasks. This, of course, might have been due to a somewhat different interpretation of the three-stage scoring process. In the present research, a determined effort to give the preoperational child credit for what he could do was made through detailed scoring procedures and by not giving global scores for a set of subtasks. Further comparisons of the two research studies cannot be made since they used different scoring procedures and analyses. In addition, it is possible that the subject samples in the two studies differed considerably.

The clustering of responses in Stage I for the present study was primarily on the pretests for measurement, conservation, and class inclusion. This suggests that these are among the more difficult tasks. It is notable that for both groups, the pretest showed significant development of serial correspondence 3 and 4 and dichotomous sorting

prior to double seriation and several measurement and conservation abilities. The reader should recall that all groups made significant gains on the seriation subtasks and the dichotomous sorting task in the longitudinal analyses while not evidencing such gains in other concept domains. The seriation subtasks are represented by serial correspondence 3 and 4 in the within-stage correspondence analysis. This result would indicate that seriation and sorting abilities are developmental precursors of the abilities represented by the more difficult measurement and conservation subtasks. Transitivity, which involves both seriation and measurement abilities, also showed significant development prior to several measurement subtasks. Double seriation, reproduction also seems to develop prior to double seriation, transposition, (though differences are not statistically significant); this is in agreement with the findings of MacKay et al. (1970), and Hooper et al. (1974).

The posttest showed considerable development of transitivity prior to serial correspondence 3 and 4; dichotomous sorting; double seriation, transposition; cross classification; and conservation of substance, prediction and deformation. This result is in contrast to results of Piaget et al. (1960), who found that serial ordering was a prerequisite to transitive understanding. Murray and Youniss (1968) also found that serial ordering was a prerequisite, although their transitivity task differed somewhat from the task used in the present research. The other seriation subtasks were not included in this analysis, and these seriation abilities may develop prior to transitive abilities. However, the results confirm findings of Toniolo & Hooper (1975) and Brainerd (1973b) that transitivity precedes conservation which in turn precedes class inclusion. The results suggest that several of the measurement tasks--distance via reference length and distance via units--are even more difficult than the conservation tasks. This is in agreement with the findings of Wohlwill et al. (1969) that measurement abilities continue to develop after subjects have reached Stage III on conservation tasks. Conclusions must remain equivocal, however, since the difference could be explained in terms of varying task demands (ie., performance variables) rather than in terms of the acquisition order of specific intellectual abilities.

From the results of the within-stage correspondence analyses, an order of difficulty of the subtasks may be inferred. The order below ranks the subtasks from least difficult (number 1) to most difficult (number 3 for the pretest and number 4 for the posttest).

Pretest

1. serial correspondence 3 and 4, dichotomous sorting
2. cross classification, class inclusion
3. conservation, transitivity,
   distance via reference length,
   distance via units

Posttest

1. transitivity
2. serial correspondence 3 and 4, dichotomous sorting
3. conservation, cross classification
4. distance via reference length,
   distance via units, class inclusion

In addition, contrary to one interpretation of Piagetian theory that indicates that a bimodal distribution of performance can be expected on a given battery of tasks, this research found that most responses on both the pretest and posttest fell into the transitional Stage II. For a more detailed discussion of these results, see Bingham-Newman (1974) and Saunders (1976, in preparation).

In general, the within-stage correspondence analysis revealed that different children follow different paths to the same place. Not only is the route different for individual children, but the pace is different; the departure from synchrony is more random than systematic. Thus the data support Flavell's (1971) contention that while integration may be characteristic of the final period in the development of structure, or structure d'ensemble, it need not characterize the manner in which structural components develop. As Wohlwill (1973a) suggests, asynchrony appears to be undeniable, yet there is undoubtedly some degree of order and regularity in the forms that the interrelationships of developing components of a structure may take. These forms of interrelationships need further longitudinal investigation.

Sex Difference Analyses

Table 29 shows the analysis of sex differences by wave with experimental and control groups combined. A cutoff point of $\gamma = .50$ was used. Wave 1 pretest comparisons revealed that girls performed significantly better pretest comparisons revealed that girls performed significantly better on height via reference length ($\gamma = .68$, $p < .05$) and boys performed significantly better on length comparison ($\gamma = -.66$, $p < .05$). The other task comparisons for Wave 1 that appear to be significant are based on only one or two cases because of tied responses. Wave 1 posttest comparisons indicate that the girls did significantly better on dichotomous sorting ($\gamma = .63$, $p < .05$), successive seriation ($\gamma = 1$, $p < .01$), additive seriation ($\gamma = 1$, $p < .05$), double seriation, reproduction ($\gamma = .76$; $p < .05$), transitivity ($\gamma = 1$, $p < .05$), distance via reference length ($\gamma = .84$, $p < .01$), conservation of number, prediction ($\gamma = .72$, $p < .01$) and deformation ($\gamma = .69$, $p < .05$), and conservation of length, deformation ($\gamma = .65$, $p < .05$). The better performance by the girls on serial correspondence 3 and 4 ($\gamma = .64$) and conservation of length, prediction ($\gamma = .62$), however, was not significant. Boys performed significantly better only on absolute seriation ($\gamma = -1$, $p < .05$).

The Wave 2 pretest comparisons for sex differences indicated that the girls performed significantly better on relative seriation ($\gamma = .59$, $p < .05$) but not significantly better on conservation of number, deformation ($\gamma = .56$), and conservation of substance, deformation ($\gamma = .64$). Posttest comparisons for the same group indicate that boys performed significantly better on conservation of number, prediction ($\gamma = -.61$, $p < .05$), but not significantly better on height via reference length ($\gamma = -.51$). Girls performed better, however, on the posttest comparisons of class inclusion and cross classification, transposition.

The posttest results showing a notable increase of female superiority in Wave 1 but not in Wave 2 may be indicative of a cohort and/or program

TABLE 29

SUMMARY OF GAMMA VALUES FOR SEX DIFFERENCES ANALYSIS--PRETEST AND POSTTEST: WAVE 1, EXPERIMENTAL AND CONTROL GROUPS COMBINED, AND WAVE 2, EXPERIMENTAL AND CONTROL GROUPS COMBINED

	Pretest				Posttest			
	Wave 1 P_1 & C_1		Wave 2 P_2 & C_2		Wave 1 P_1 & C_1		Wave 2 P_2 & C_2	
	γ Val.	Sign. Level	γ Val.	Sign. Level	γ Val.	Sign. Level	γ Val.	Sign. Level
Dichotomous Sorting	-.09	ns	.41	ns	.63	.05	.29	ns
Class Inclusion	Not given		-.20	ns	.48	ns	.62	.05
Cross Classification, Reproduction	Not given		.0	ns	.49	ns	-.29	ns
Cross Classification, Transposition	Not given		.11	ns	.45	ns	.68	.01
Seriation								
Absolute	-1.0	.001	-.03	ns	-1.0	.05	-.17	ns
Relative	-.08	ns	.59	.05	.03	ns	-.24	ns
Successive	0	ns	-.33	ns	1.0	.01	-.01	ns
Additive	-.21	ns	-.13	ns	1.0	.05	.24	ns
Serial Correspondence 1	Not given		-.13	ns	.64	ns	.44	ns
Serial Correspondence 3 & 4	.19	ns	.12	ns	.33	ns	.04	ns
Double Seriation, Reproduction	Not given		.11	ns	.76	.05	-.21	ns
Double Seriation, Transposition	Not given		-.45	ns	.25	ns	.39	ns
Transitivity	Not given		-.12	ns	1.0	.05	-.18	ns
Measurement								
Length Comparison	-.66	.05	.03	ns	-.03	ns	.28	ns
Distance via Reference Length	1.0	ns	1.0	ns	.84	.01	.46	ns
Distance via Units	-.17	ns	1.0	ns	.30	ns	.41	ns
Height via Reference Length	.68	.05	.06	ns	*		-.51	ns
Area via Units	0	ns	-.31	ns	.16	ns	-.06	ns
Conservation								
Number, Prediction	Not given		.16	ns	.82	.01	-.19	ns
Number, Deformation	Not given		.56	ns	.69	.05	-.01	ns
Number, Adjusted	Not given		*		*		*	
Length, Prediction	Not given		.37	ns	.62	ns	-.61	.05
Length, Deformation	Not given		0	ns	.65	.05	-.08	ns
Length, Adjusted	Not given		*		*		*	
Substance, Prediction	Not given		.22	ns	.20	ns	-.10	ns
Substance, Deformation	Not given		.64	ns	.14	ns	.09	ns
Substance, Adjusted	Not given		*		*		*	

*All subjects in both groups were in Stage I.

effect. In neither wave, however, were female performance leads on the pretest carried over to the posttest. Rather, female superiority on the posttest was obtained on a different subset of the task battery. In a re-examination of the anecdotal records for the Wave 1 experimental group, it was found that the boys spent a great deal of time in large motor and dramatic play activities that the girls were often hesitant to join. Theoretically, and from the orientation of the program, this should not have excluded the boys from experiences utilizing the Piagetian operational abilities since these abilities were considered a component of all activities. It is possible that a cohort effect brought about by an increased emphasis on women's liberation may have been present. Parents of the Wave 2 subjects became particularly aware of the movement during the two years their children were in the program. The elimination of sex stereotyping in children's activities became a particular concern of the teachers in the PPEP during this period.

Core group *t*-test comparisons were carried out on the age variable and the standardized measures, PPVT and Raven CPM, to determine whether sex differences were apparent (see Table 30). For Wave 1 there were no significant differences on the pretest or posttest for either the experimental or control group. For Wave 2, the only significant difference was for the control group age variable; this variable indicated that the girls were significantly older ($t = 3.65$, $df = 8$, $p < .01$). It is interesting to note that although the girls in the Wave 2 control group were significantly older than the boys, they did not perform better.

Time-Lag Analyses

The last analyses dealt with putative causal linkages in performances among the Piagetian tasks from pretesting to posttesting. The data were rearrayed for the time-lag analyses so that each comparison looked at an individual's performance on one task at the pretest and his/her performance on a different task at the posttest to see if there was any indication that a predictive causal linkage was involved. The waves for the experimental groups and the waves for the control groups were combined for a separate analysis (see Tables 31 and 32). The three distinct patterns apparent in the data are (1) a high stage score on the pretest task followed by a low stage score on the posttest task, (2) a low stage score on the pretest task followed by a high stage score on the posttest task, and (3) Stage I responses on both the pretest and posttest tasks.

Many children gave Stage I responses on both pretest and posttest administrations of a number of tasks. This may be a possible determinant of the low posttest task responses relative to pretest task responses in the first pattern. The control group had ten comparisons in this pattern, while the experimental group had only three. This is supportive of the finding that the experimental groups evidenced a greater spread of responses across stage categories on the posttest than the control groups did, and suggests a possible program effect. The third pattern, with responses in Stage I on the pretest task and on the posttest task, included area via units by conservation of number, deformation, and by

TABLE 30

CORE GROUP COMPARISONS OF SEX DIFFERENCES FOR WAVE 1 AND WAVE 2: PRETEST AND POSTTEST

	P_1				C_1				P_2				C_2			
	Pretest		Posttest		Pretest		Posttest		Pretest		Posttest		Pretest		Posttest	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Age																
N	8	4	8	4	4	4	4	4	10	8	10	8	6	4	6	4
Mean	41.00	39.25			42.25	41.25			41.20	40.25			38.33	43.75		
SD	4.69	2.75			4.99	6.23			2.74	3.57			2.50	1.89		
t	.67				.25				.63				3.65*			
PPVT																
N	8	4	8	4	4	4	4	4	10	8	10	8	6	4	6	4
Mean	36.87	46.25	53.25	53.00	48.25	48.00	58.50	53.25	44.90	34.87	55.00	52.62	39.50	51.00	58.33	59.25
SD	12.00	4.11	5.28	7.39	8.46	8.28	3.69	6.89	5.56	16.61	8.47	7.02	12.53	5.29	8.31	4.78
t	1.48		.06		.04		1.34		1.79		.87		1.70		.19	
Raven CPM																
N	8	4	8	4	4	4	4	4	10	8	10	8	6	4	6	4
Mean	14.25	16.00	13.12	15.25	11.75	12.00	15.00	13.75	10.10	10.50	13.40	12.50	8.00	12.00	16.83	14.25
SD	3.28	2.16	2.29	.95	2.21	1.82	4.69	1.70	2.23	3.62	3.43	4.03	3.52	1.82	1.47	2.21
t	.95		1.74		.17		.50		.28		.51		2.06		2.23	

* $p < .01$.

TABLE 31

SUMMARY OF GAMMA VALUES FOR TIME-LAG DATA FOR EXPERIMENTAL GROUP--WAVE 1 AND WAVE 2 COMBINED

				Measurement					Conservation					
Pretest	Double Seriation, Reproduction	Double Seriation, Transposition	Transitivity	Length Comparison	Distance Via Reference Length	Distance Via Units	Height Via Reference Length	Area Via Units	Conservation of Number, Prediction	Conservation of Number, Deformation	Conservation of Length, Prediction	Conservation of Length, Deformation	Conservation of Substance, Prediction	Conservation of Substance, Deformation
Absolute Seriation	.45	.28	.36	.26	-.05	1.0*	.43	.46	1.0**	.47	1.0*	1.0	1.0**	.41
Relative Seriation	.02	-.08	.23	.71	-.13	-.28	-.10	.04	-.04	.09	-.28	-.06	.04	.01
Successive Seriation	.09	.33	.39	-.23	-.13	.10	-.32	.49*	-.38	-.08	.07	-.03	.09	.28
Additive Seriation	-.10	-.17	-.09	-.10	-1.0**	-.44	.54	.12	.18	-.04	.31	.29	.24	-.05
Serial Correspondence 1 †	.14	-.22	-.18	-.06	.21	-.06	-.25	-.11	.35	.45	-.08	.44	.63**	.38
Serial Correspondence 3 & 4 †	-.24	0	-.14	.32	-.42	-.73**	-.79*	-.16	-.27	.01	.11	.21	-.14	-.25
Double Seriation, Reproduction †	0													
Double Seriation, Transposition †		.08												
Transitivity			.33											
Length Comparison	.28	.18	.08	.07					.27	.40	.17	.42	.41	.49*
Distance Via Reference	1.0	1.0*	1.0		.79*				1.0	-1.0	-1.0	-1.0	-1.0	.48
Distance Via Units	1.0	.81*	1.0			.41			.48	.14	.02	.39	.33	.48
Height Via Reference Length	.58*	.40*	.84***				-.02		.23	.57*	.47	.44	.56**	.30
Area Via Units	.59	-.22	.46					.04	.21	.71**	.30	.46	.79**	.41

* $p < .05$
** $p < .01$
*** $p < .001$
† P_2 only.

TABLE 32

SUMMARY OF GAMMA VALUES FOR TIME-LAG COMPARISONS FOR CONTROL GROUPS--WAVE 1 AND WAVE 2 COMBINED

				Measurement					Conservation					
Pretest	Double Seriation, Reproduction	Double Seriation, Transposition	Transitivity	Length Comparison	Distance Via Reference Length	Distance Via Units	Height Via Reference Length	Area Via Units	Conservation of Number, Prediction	Conservation of Number, Deformation	Conservation of Length, Prediction	Conservation of Length, Deformation	Conservation of Substance, Prediction	Conservation of Substance, Deformation
Absolute Seriation	.37*	.48**	-1.	-.15	1.0	1.0*		.68	-.11	.20	-.32	.12	—	.33
Relative Seriation	.03	-.02	-.37	-.32	-.16	-.18		-.16	-.70*	-1.0	-.28	-.45	-.65	-.65
Successive Seriation	-.31	-.35**	.05	-.20	-.43	-.63*		-.77*	.18	-.26	.28	.22	.27	.27
Additive Seriation	-.40*	-.30	.26	-.13	-.68*	-.62*		-.09	-.48	-.33	-.60	-.14	-.20	-.20
Serial Correspondence 1 †	.18	.08	1.0			-.38		-.83**	.30	.33	.89**	.85*	.33	.33
Serial Correspondence 3 & 4 †	-.17	.03	-1.0	.35	-.25	-.51		.54	.11	.05	.05	-.27	.22	.22
Double Seriation, Reproduction †	.57													
Double Seriation, Transposition †		-1.0												
Transitivity			1.0											
Length Comparison	.46	.80**	-1.00**	.39					.42		-.49	.30	.87**	.87**
Distance Via Reference Length	1.0	.82	-1.0**		1.0*				1.0	1.0	-1.0	-1.0	1.0	1.0
Distance Via Units	1.0	.82	-1.0**			1.0*			1.0	1.0	-1.0	-1.0	1.0	1.0
Height Via Reference Length	.45	.28	.13				-.02		-.46	-.32	-.67*	-.41	-.14	-.14
Area Via Units	-.41	-.15	-.16					-.02	.67*	.52	.61*	.22	.38	.38

* $p < .05$
** $p < .01$
† C_2 only.

conservation of substance, prediction, for the experimental group. The control group comparisons for the same pattern type included successive seriation by double seriation, transposition; successive seriation by distance via units; successive seriation by area via units; area via units by conservation of number, prediction; and area via units by conservation of length, prediction.

The pattern type that is by far the most interesting is the second one, in which a lower pretest stage is indicative of a higher posttest stage. The following are the cases that fit into this pattern for the experimental group:

Pretest	Posttest
serial correspondence 3 and 4	by height via reference length
distance via reference length	by double seriation, transposition
distance via units	by double seriation, transposition
dichotomous sorting	by cross classification, reproduction
dichotomous sorting	by cross classification, transposition
dichotomous sorting	by absolute seriation
dichotomous sorting	by successive seriation
dichotomous sorting	by additive seriation
dichotomous sorting	by serial correspondence 1
dichotomous sorting	by serial correspondence 3 and 4
dichotomous sorting	by double seriation, reproduction
dichotomous sorting	by transitivity
cross classification, reproduction	by relative seriation
cross classification, reproduction	by area via units
cross classification, transposition	by relative seriation

The control group comparisons that fit into the second time-lag pattern are the following:

Pretest	Posttest
additive seriation	by double seriation, reproduction
length comparison	by double seriation, transposition

Pretest	Posttest
length comparison	by transitivity
length comparison	by conservation of substance, prediction
length comparison	by conservation of substance, deformation
distance via reference length	by transitivity
distance via units	by transitivity
dichotomous sorting	by successive seriation
dichotomous sorting	by serial correspondence 1
dichotomous sorting	by serial correspondence 3 and 4
cross classification, reproduction	by cross classification, reproduction

The difference in the comparisons for the experimental and control groups in the time-lag analysis suggests a possible program effect. As mentioned above, the experimental group had only one-third as many high to low comparison patterns as the control group (3 and 10, respectively); moreover, the experimental group had more low to high comparison patterns than the control group (15 and 11, respectively). In addition, the experimental group revealed a fourth pattern type that the control group did not exhibit. In this pattern, Stage I on the pretest was indicative of Stage I on the posttest but Stage III on the pretest was indicative of any stage from III to I on the posttest. This result may be evidence of a possible statistical regression or measurement error effect. There were four cases of this type: absolute seriation by distance via units; absolute seriation by conservation of number, prediction; absolute seriation by conservation of length, prediction; and absolute seriation by conservation of substance, prediction.

In many cases no particularly discernible pattern was exhibited. Of all the time-lag comparisons, very few were significant in both groups. Out of 63 significant comparisons only 11 were shared by the two groups. Overall, very different predictability patterns were found. Individual pattern differences were as great as, if not greater than, group differences. Some children appeared to spend a long period in the transitional Stage II on some tasks while others moved fairly quickly from Stage II to Stage III. It was not possible to discern whether the latter children skipped Stage II entirely or whether they were in this stage between testings. Actual skipping of Stage II would contradict the theoretical assumption that stages of reasoning are invariant. It was not possible to determine whether horizontal décalage-convergence (Model II-A of Wohlwill, 1973b) occurred without a third testing period for comparison. It may turn out that different types of convergence or reciprocal interaction (Model III) occur for different individuals.

Neither the PPEP nor the CNSP emphasized the conformity often required in later school experiences. The PPEP was particularly accepting of each child's individuality throughout all areas of the program. This factor may have carried over to allow the children to be intellectually honest in testing situations also. The care taken in making the testing situation for all subjects a comfortable and pleasant experience undoubtedly also contributed to the expression of individuality by subjects in both groups, thus resulting in greater across-task variability.

Nonstatistical Considerations

Subjective impressions of parents, teachers, and testers and anecdotal records kept by the teachers were also used in evaluation. Teacher evaluations of the general effectiveness of the PPEP were most positive. Teachers indicated that children's attitudes toward problem solving and their approaches to unfamiliar materials, people, and events changed markedly over the two-year span. Anecdotal records on the spontaneous actions of children in the classroom indicated that the children were making progress in terms of the Piagetian operations at issue. In many instances spontaneous seriation and measurement responses, as well as the beginning of an awareness of conservation, were recorded. Testers spontaneously stated that they felt that the children in the experimental group were using a greater variety of approaches and solutions to the tasks than the children in the control group. The children's responsiveness to the general teaching framework was reflected in the positive reactions of the parents. Parents were eager to give accounts of experiences in the home and were curious about the activities that were done at school. There was also general encouragement for extension and elaboration of the project into a kindergarten and first-grade program.

CONCLUSIONS

In conclusion, the differential effectiveness of the PPEP was not established in the present research. While this finding may be taken at face value, numerous other analyses provided information on a variety of changes occurring in early childhood. One of the most interesting findings was the wide variety of asynchronous patterns of developmental change. If the encouragement of individuality leads to asynchronous development, the increased use of programs such as the PPEP could result in changes in the developmental patterns found in previous research.

The findings of synchrony and a universal sequence of development in previous research may be reflections of the universal expectations of conformity by societies. Although cultures differ, each society has generally expected its children to conform to its cultural patterns. Perhaps Piaget's universal findings, which heretofore have been thought to be relatively invariant across sociocultural settings, only apply to a relatively stable world where dependence on previously established cultural patterns is helpful. The present emphasis on preparation for constant and usually unpredictable change requires a break from such conformity. Divergence from old patterns is essential for continued adaptation to a rapidly changing society. Research findings of unsystematic asynchrony may reflect very real cohort differences rather than contradict previous findings. It is paradoxical that programs that are based on Piagetian theoretical assumptions and that stress individuality (e.g., the British infant schools, open classrooms, and the PPEP) may require adaptation of Piagetian theory if cognitive development in future generations is to be accurately described. Piaget (1970b) spoke to this point when he said:

> If we desire, in answer to what is becoming an increasingly widely felt need, to form individuals capable of inventive thought and of helping the society of tomorrow to achieve progress, then it is clear that an education which is an active discovery of reality is superior to one that consists merely in providing the young with ready-made wills to will and ready-made truths to know with [p. 26].

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Technical Report No. 354
(Part 2 of 2 Parts)

LOGICAL OPERATIONS INSTRUCTION IN THE PRESCHOOL

by

Ann M. Bingham-Newman, Ruth A. Saunders,
and Frank H. Hooper

Report from the Project on
Conditions of School Learning and Instructional Strategies

Frank H. Hooper
Faculty Associate

Wisconsin Research and Development
Center for Cognitive Learning
The University of Wisconsin
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April 1976

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Final Report--Hatch Research Project 142-1769
July 1, 1971, to August 30, 1974

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WISCONSIN RESEARCH AND DEVELOPMENT CENTER FOR COGNITIVE LEARNING

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ABSTRACT

This research represents a direct attempt to integrate developmental theory with the more applied field of education in order to achieve a more thorough understanding of each. The study had two major foci: (1) to develop, implement, and evaluate an experimental preschool education program based on Piaget's theory of cognitive development, and (2) to examine Piaget's theoretical assumptions and postulated cognitive developmental trends for a two-year period of the preoperational substage. Aspects of cross-sectional and longitudinal designs were incorporated into the pretesting and posttesting of two overlapping waves of experimental and control group populations of preschool children over a period of three years.

A core group of 48 subjects, aged 3 to 5 years, remained with the project for the full two-year period desired for each wave. The subjects were evaluated with two standardized measures--Peabody Picture Vocabulary Test (PPVT) and RAVEN Coloured Progressive Matrices (Raven CPM)--and a representative battery of eight Piagetian tasks. The differences in developmental patterns between the experimental and control groups were examined with tasks of seriation, classification, transitivity, conservation, measurement, and class inclusion and with two matrix tasks (double seriation and cross-classification). Within the general area of the acquisition of cognitive abilities, normative longitudinal and cross-sectional analyses were utilized to examine within-stage intra-individual performance correspondences, developmental sequences in task performances, experimental and control group differences, and sex differences in task performance. In this research the assessment of children's thought processes was of more concern than the accumulation of pass/fail data.

The experimental group program included a teacher education component and a framework for curriculum decisions guided by nine principles from Piagetian theory. It focused on the understanding of seriation, classification, number, and spatio-temporal relations in a wide variety of spontaneous, yet integrated, experiences. Integrated experiences here refer to what Wohlwill (1970), and Strauss (1972) claim lead to optimal development of logical operations--that is, the development of operations in conjunction and collaboration with one another as part of a total structure rather than in isolation. The control group attended a conventional preschool.

Cross-sectional analyses using the Goodman-Kruskal gamma statistic indicated no outstanding differences between the performances of the experimental and control groups. Longitudinal analyses using the gamma statistic revealed significant gains on several of the Piagetian tasks and subtasks for both groups. In general, normative analyses indicated typical performance patterns for three- and five-year-old subjects, with a notable degree of individual differences in patterns of performance

and absolute level of performance. Pretest to posttest *t*-test comparisons of the non-Piagetian measures revealed significant gains for all subjects on the PPVT and for only the Wave 2 control group on the Raven CPM.

An analysis of within-stage correspondence, within and across concept domains, indicated a notable lack of synchrony, with many individual patterns in both the experimental group and the control group. These results are supportive of previous work by Flavell (1971), Turiel (1969), and Wohlwill (1973b) which suggests that a high degree of structural mix in response patterns can be expected during the transitional preoperational period. Pretest responses often clustered in Stage I, while posttest responses were generally spread across all response categories (i.e., Stages I, II, and III with associated substages). Sex differences were found for the non-Piagetian measures but were notably absent in the Piagetian measures. A time-lag analysis was performed to reveal any evidence of causal linkages from performance on one task at the pretest to another task at the posttest. Very few of these comparisons were statistically significant. However, very different predictability patterns were found for the experimental and control groups. Because of this factor, unequivocal inferences about predictability for the present treatment conditions during the preoperational period cannot be made.

Although Piagetian theory provided a very workable and stimulating foundation for a preschool curriculum, program effects in this research were greatly overshadowed by the large amount of individual variation in the rate and sequence of cognitive developmental acquisitions in the preoperational stage. The almost complete asynchrony evidenced in the development of various operations assuredly brings into question those interpretations of Piagetian theory that depend on synchronous emergence and cohesive, well-integrated structures at all stages of development. This research suggests that, regardless of how synchronously operations develop in later stages, they follow a more diverse pattern in the preoperational stage.

APPENDIX A

SAMPLES OF WEEKLY PLANNING GRIDS, WEEKLY SMALL GROUP AND JUICE TOPICS, AND THE FORMATIVE EVALUATION METHOD FOR SMALL GROUP ACTIVITIES

Group 2 Year 2 Sem. I

Week 5

Teachers: Discuss experiences of home visits. Look at child as member of a family as well as member of a peer group. What does this mean for him? To him? Is he glad to be a part of his family? Is his family life reflected in his play at school?

Change bulletin boards.

Begin to notice and record spontaneous Piagetian types of behavior and thinking.

Small Groups:

1. Number (getting juice and crackers ready)
2. Number (bean bags and the old shell game)
3. Classification and Representation (what goes together)
4. Number (dice game)

Juice Topics:

1. Can you think of something larger than a _____? Repeat.
2. What if you went to a school that had no toys? What would you do all day?
3. What do you like better, a _____ or a _____? Repeat.
4. What do you hate the most? Love the most?

Planning Grid for Week #5
Week of _____

Area	Tuesday	Wednesday	Thursday	Friday
Large Group	Easel story	Slides of children outside	Little engine that could	Rhythm and matching rhythms
Art	Art mural on wall (one scene chalk)	Field trip for nature objects Spatter painting	Overhead projector & clear paper--draw picture and get in light	Block light Day glow
Science	Experiment with fizzy stuff, baking powder, vinegar	Make bread	Plant seeds or water table (float sink)	
Small Manipulative	Doll house, few dolls and furniture, teddy bear and mouse counters, two sets of Montessori cylinders, opening face puzzles, seriation fish and mirrors		Farm Set Flannel Board	
			House puzzle	Texture box
Dramatic Play	Pioneers, explorers, extension of camping play from last week.			
	Prepare for trip Scavenger hunt	Actual journey	Homesteading Long skirts, shawls	Corn husking
Books	Henry the Explorer Book with pictures of national parks Imagination books Edith and Big Bad Bill			
Large Manipulative	Blocks--Leave out tape roads, build some houses Build new roads, learn how to get from one place to another Tiny cars and people			
Music	Ear phones & African drum record	Wooden Xylophone	Metal Xylophone (Glockenspiel)	Tape recorder with sounds to match
Juice	Fresh vegetable	Bread (Muffins) & white milk	Juice & crackers	Corn on cob
Outside	If rainy wheelbarrows, wagons, & blankets	Balance workshop (unit blocks, string, balance beam) Tin can stilts, roller skates inside		
		River on hill	Digging & raking equipment	Same

Small Group Card

Week #5

M O--Classification and Representation
Rep--Three dimensional
S E--Visual, tactile
V E--Colors, sizes, shapes, functions

Materials: Tray of assorted objects (about 12)

Activity: Show children the tray of objects. Encourage them to look at the objects and think about how they could go together. Let each child have a turn choosing two things which go together. Have child tell "why" they go together. Can go to choosing four items that go together, etc. Encourage children to do something different each time. Or, one child could choose two things that go together and she/he could choose someone else to guess why, or the group could guess why.

Date: Week: Teacher: # of Group: Child's Name:	Uses language to represent actions or relationships of objects	Representation with objects bears resemblance to reality	Classifies materials around an idea, i.e., garage, eating, function	Classifies materials around attributes, i.e., color, size, etc.	Shifts criteria second time around	Comments

*Evaluation card adapted from form used at Pennsylvania State University program (S. Willis, Coordinator).

Small Group Card

Week #5

M O--Number
Rep--Three dimensional
S E--Tactile, visual
V E--One, two, three, four, five, six, dice, roll

Materials: One die, small bags, baskets of collage material, paste and paper.

Activity: Choosing material for a collage.
Child must roll die and can only take as many things as the number indicates to put in his/her bag. Let children repeat several times reminding them it is for a picture. When they come back to group tell them they can have paste and paper now if they would like.
Could write numeral on big paper as child counts, indicating this represents number of dots on face of die.

Evaluation of Small Group

Date: Week:
Teacher:
Type of Group:
# of Group:

Child's Name	Can discuss # of dots on die	Corresponds one object with each dot on die	Shows interest in writing numeral	Writes numeral on picture when done	Comments

Week 20: Work with 562 students (orientation to classroom)

Work on teacher techniques. Try out a variety and observe children's reactions carefully.

Observe variety of interpersonal techniques and results of their use: (1) between teacher and child and (2) between child and child.

Juice:

1. What foods are your favorites; which do you dislike?
2. What makes you happy?
3. What if you didn't have a mouth, how could you eat? (ears, nose, etc.)
4. What can this be? (cracker shapes, napkins, etc.)

Small Groups:

1. Time interval (stop-and-go games)
2. Grouping and regrouping (flannel board families)
3. Size as an attribute (match identical sizes)
4. "What can this be?" (divergent thinking)

Planning Grid for Week #20
Week of _____

Area	Monday	Tuesday	Wednesday	Thursday
Large Group	Story of Three Bears, flannel board & kids to act it out	Sesame Street song with flannel board "One of these things is not like the others"	Puppet telling a story	Make applesauce (go through sequence of activities)
Art	Mural--paint on brown paper (vertical)	Mural--collage on floor	Make valentines, doilies, cloth	Water colors
Science	Make popcorn	Take apart bike	Swinger camera	Make applesauce
Small Manipulative	Design blocks & cards Different kinds of puzzles Shape lotto (2 cards) New shape puzzles (plastic) Little hammers & nails		Blocks but no cards Add cards or change cards Rubber shape puzzles Beads (big ones)	
Dramatic Play	Office (typewriters) Extend to hospital on Wednesday			
Books	Insect books Grocery store books Award winning storybooks			
Large Manipulative	Two level building, top part enclosed Piles of building materials (different each day)			
Music	Montessori bells	Records and earphones Songs to sing along with	Rhythmic songs on records	Records and earphones Songs to sing along with
Juice	Popcorn and grape juice	Whipped jello applesauce & graham crackers	Barney is bringing valentines, snacks, water	Applesauce Oyster crackers, apple juice
Outside	Different levels of climbing equipment Junk pile Snow equipment (if weather cooperates) & bikes			

Small Group Card Week #20

M O--Preclassification, seriation, size as an attribute (matching identical objects when various sizes are shown)
Rep--Symbol
S E--Visual (small size differences)
V E--Words (small, smaller, smallest; large, larger, largest)

Materials: Objects differing only in size (5 sizes, 3 of each)
Can use rectangles (yellow or blue), wooden blocks, straws, spoons, etc.

Activity: Give each child a different sized object. Ask him to find everything that is the same size.
Try going on to finding things that are "smaller" or "larger."

Small Group Card Week #20

M O--"What can this be?" (divergent thinking--what they let object be, what others use it for)
Rep--Make believe
S E--Visual
V E--Imaginative expression in words

Materials: Block, paper shapes, clay, etc.

Activity: Teacher asks, "What can this be?" and lets children show group their ideas. "What can we make this into?"
Asks what this could be if child were a tiny fly, a huge giant, etc.

APPENDIX B

TASK PROTOCOLS, SCORING PROCEDURES, MATERIALS

RAVEN COLOURED PROGRESSIVE MATRICES
(Adapted for use with 3-5 year old children)

SET A

Introduce the task by saying, "I have a picture game to play with you." Open the book to A-1, cover the bottom half, and say, "Look, here is a picture (design, puzzle), but it has a piece missing (indicate), doesn't it? Now (uncover the bottom half), here are some pieces you can use to finish the picture (puzzle). Look carefully, each piece is the right shape to fit the space, but only one is the right pattern. What about this one (point to No. 1), the lines go the wrong way, don't they (point to No. 2)? Is this it? No, it doesn't even have a pattern. Look at this one (No. 3). It's the wrong colors, isn't it? Let's look at this one (No. 6); they left out some of the design(pattern) so it doesn't go. Now look at these two pieces (Nos. 4 and 5), and tell me which one goes here (point to blank)." If the child does not choose the correct piece, continue the explanation until the child understands the directions.

Turn to A-2, cover the bottom half and explain, "Here is another design (pattern, puzzle); it has a piece missing too. Show me where the piece is missing. Good, now (uncover bottom) here are some extra pieces. Look carefully at each piece (point to each piece) and show me which piece goes here (blank)." If the child does not answer correctly, return to A-1 and demonstrate again. (Remember, each piece is the right shape, but only one has the right design. Look carefully at each piece and show me which goes in here.) Then go back to A-2 and ask again. After he/she answers a second time (whether correct or incorrect) go on to A-3. Repeat this procedure for A-3, A-4, and A-5. If

the child does not answer correctly the first time go back to A-1, demonstrate again and return to where he/she was.

Continue with A-6. For A-6 to A-12, accept the child's first choice and continue. Do not go back to A-1. Each time be certain the child looks carefully at the pattern and at all six alternatives. Continue with this section until A-12 or until the child makes three mistakes in a row. Then go to Set Ab.

SET Ab

Turn to Ab-1, cover the bottom half and explain, "Here's another kind of design (pattern, puzzle). Look, here's a part (top left), here's another part (top right), here's another part (bottom left), but this part is missing (blank). Now (uncover bottom), here are some extra pieces. Look carefully at each piece (point to each) and show me which one goes in here (blank). Continue the directions until the child has chosen the correct piece, then go to Ab-2.

After the child has pointed to one of the pieces in Ab-2 ask, "Is that the piece to go in here (point to blank)?" If the child says "yes" accept his/her choice and go to Ab-3. If the child wants to change his/her choice, say "OK, look at all the pieces again and show me which one goes here." After she/he has chosen again ask, "Is that the piece that goes here?" Continue this procedure until the child is satisfied with his/her answer. Then go on to Ab-3.

Present Ab-3, Ab-4, and Ab-5 exactly as Ab-2. For Ab-6 to Ab-12, accept the child's first choice and continue. Continue with this set until Ab-12 or until the child makes three mistakes in a row. Then go to Set B.

SET B

Present Set B exactly as Set Ab was presented. Continue with this set, until B-12 or until the child has made three mistakes in a row.

REMEMBER:

1. Record time at beginning and end of session.
2. As you present each page, cover the bottom half.
3. For each page, make sure that the child looks at all six alternatives.
4. For each item, record the number of the child's selection (or selections) on the standard score sheet.
5. Continue each section until the end or until the child makes three mistakes in a row.

I. CLASSIFICATION TASKS

Warm Up

The examiner randomly places all blocks before the child and says, "Here are some blocks for us to work with. Tell me what you see. (Tell me about them)."

If the child does not spontaneously say "red," "blue," "circle," "square," "big," "little," the examiner picks up two blocks for contrast and asks the child, "How are these different?" or "What's different about these?"

If the child does not respond to these questions, the examiner continues to probe for understanding of attributes, holding up blocks and asking questions such as:

"Are these the same size (color, shape)?" "Which one is bigger?"

"Is this one just as big as this one?" "Which one is bigger?"

"This one is big. Show me one that is just as big."

The examiner continues until the child has correctly verbalized or matched all the attributes.

To conclude the warm up the examiner says, "Good, you've told me (shown me) there are square blocks and circle blocks, blue blocks, and red blocks, big blocks, and little blocks.

Go on to Free Sort

Free Sort

Sorting Instructions

The examiner places all blocks randomly before the child and says, "Put together all the blocks that go with each other (that go together)." The examiner does not use the words "alike" or "different."

Directions may be repeated three or four times, but the child should not be pushed.

When the child seems to be finished, the examiner asks if she/he has all the blocks the way he/she wants them to be, then goes on to the justification.

Justification

The examiner compliments the child's work saying, "Good _____ (name), you've really been thinking about where to put these blocks" or "That's an interesting way to sort the blocks." She/he then inquires, "How did you know (decide) to put them together like this?" "Can you tell me why all these (pointing) go together?" or "I wonder how you decided on that."

Go on to the first Dichotomy regardless of the child's response (or lack of it).

Dichotomous Sorting

FIRST SORT

Sorting Instructions

The examiner mixes all the blocks, puts two boxes in front of the child (one on either side of the blocks), and says, "Now I want you to put (divide) these blocks into two bunches. Put one kind in this box and one kind in this box." If the child puts only one block in each box, the examiner says, "Put all the blocks into the boxes the way they go together" or "Put one bunch in this box and one bunch in this one."

Directions may be repeated three or four times, but the child should not be pushed.

The examiner makes sure that the child is finished before asking for a justification.

Justification

The examiner compliments the child's work saying, "Good _____ (name), you've really been thinking about where to put these blocks" or "That's an interesting way to sort the blocks." She/he then inquires, "How did you know (decide) to put them together like this?" "Can you tell me why all these (pointing) go together?" or "I wonder how you decided on that."

End the session if the child has not responded.

Go on to the second sort if the child has made a response of any kind.

SECOND SORT

Sorting Instructions

The blocks are again mixed and the examiner says, "Last time you separated the two _____ (colors, shapes, sizes)." (Omit this sentence if child has not made a dichotomy.) "This time make two bunches in another way. Put one kind in here and one kind in here. Remember, do it in a different way, a new way."

Directions may be repeated. The examiner makes sure the child is finished before asking for a justification.

Justification

The examiner compliments the child's work saying, "Good _____ (name), you've really been thinking about where to put these blocks" or "That's an interesting way to sort the blocks." She/he then inquires, "How did you know (decide) to put them together like this?" "Can you tell me why all these (pointing) go together?" or "I wonder how you decided on that."

End the session if the child does not respond.
Use demonstration dolls if the child has repeated his first sort.
Go on to third sort if the child has made two different sorts.

DEMONSTRATION--SHIFTING CRITERIA

Use if the second sort was exactly the same as the first sort.

Materials: 6 paper dolls
- 3 boys--2 holding a flower, 1 not
- 3 girls--1 holding a flower, 2 not

2 boxes

Procedure

E says, "Look what I have now--some boy dolls and some girl dolls (points to each). Some have flowers, see (indicates those), and some don't. Now, put all the boys in this box (help child if she/he needs it) and all the girls in this box." When the child has finished E compliments him/her saying, "Good _____ (name), you put all the boys in this box and all the girls in this box. Now, make two bunches in a new way. Put all the children that have flowers in this box, and all the children that don't have flowers in this box." When the child has finished E explains, "See, you made two bunches in a different way, in a new way. You put all the children with flowers in this box and all the children without flowers in this box."

THIRD SORT

Sorting Instructions

The blocks are again mixed and the examiner says, "This time make two bunches in even another way. Remember, the first time you separated the _____ (colors, shapes, sizes). Then you separated the _____ (colors, shapes, sizes). This time do it in even a different way. Remember to do it in a new way.

Directions may be repeated, but the child should not be pushed.

The examiner makes sure the child is finished before asking for a justification.

Justification

The examiner compliments the child's work saying, "Good _____ (name), you've really been thinking about where to put these blocks" or "That's an interesting way to sort the blocks." She/he then inquires, "How did you know (decide) to put them together like this?" "Can you tell me why all these (pointing) go together?" or "I wonder how you decided on that."

End the session if:

1. The child has not made any of the dichotomies.
2. The child has made only one dichotomy, but this was not the first time he made it.
3. The child has made the three different dichotomies.

Go on to the fourth sort if:

1. The child has just made his first dichotomy.
2. The child has made two of the three dichotomies.

FOURTH SORT

Sorting Instructions

The blocks are again mixed and the examiner says, "This time make two bunches in even another way. Remember, the first time you separated the _____ (colors, shapes, sizes). Then you separated the _____ (colors, shapes, sizes). This time do it in even a different way. Remember to do it in a new way."

Directions may be repeated, but the child should not be pushed.

The examiner makes sure the child is finished before asking for a justification.

Justification

The examiner compliments the child's work saying, "Good _____ (name), you've really been thinking about where to put these blocks" or "That's an interesting way to sort the blocks." She/he then inquires, "How did you know (decide) to put them together like this?" "Can you tell me why all these (pointing) go together?" or "I wonder how you decided on that."

End of session*

*Exception: If the child just made a second dichotomy, go on to a fifth sort (repeat procedures for the fourth sort).

Scoring Criteria

Acceptable dichotomy:

1. intensive and extensive properties coordinated and
2. no more than one block left out of boxes or placed incorrectly.

Dichotomies made in free situation are accepted.

Patterns are okay if a dichotomy is made.

Subgroups within a perfect dichotomy are okay.

Imperfect initial dichotomy is okay if corrected by child when asked for justification.

A relevant justification is anything that corresponds to reality and implies the criterion.

Free Sort

Name _____
School _____
Date _____
Tester _____
Scorer _____

Time _____

Approach

1. Planning
   a. seems to work things out as she/he goes along
   b. seems to have a plan in mind from the beginning
   c. can't tell

2. Criteria
   a. shifts
   b. keeps same
   c. can't tell

Product

1. No response

2. Graphic sort (describe)
   a. no obvious pattern
   b. makes a "picture" (no consistent arrangement of size, shape and/or color)
   c. obvious pattern (geometric design)
      _____ number of blocks not used

3. Non-exhaustive sort
   a. ___ blocks not sorted (which?)
   b. all blocks sorted, but ___ mistakes made (describe)

4. Exhaustive sort

If 3 or 4, is the sort according to:

a. size	e. size and color
b. shape	f. shape and color
c. color	g. size, shape, and color
d. size and shape	h. other _____

Justification

1. No justification

2. Irrelevant justification _____

_____

3. Relevant justification _____

_____

Dichotomous Sorting

Name _____
School _____
Date _____
Tester _____
Scorer _____

FIRST SORT*

Approach

1. Planning
   a. seems to work things out as she/he goes along
   b. seems to have a plan in mind from the beginning
   c. can't tell

2. Criteria
   a. shifts
   b. keeps same
   c. can't tell

Product

1. Nondichotomous sort
   a. graphic sort (describe)
      1. no obvious pattern
      2. makes a "picture" (no consistent arrangement of size, shape and/or color)
      3. obvious pattern (geometric design)
      ___ number of blocks not used
   b. nonexhaustive sort
      1. ___ blocks not sorted (which?)
      2. all blocks sorted but ___ mistakes made (describe)
   c. makes small groupings but fails to dichotomize the groups according to a set criterion
   d. equivalent sort
   e. other (describe) _____

2. Dichotomous sort

Criterion

(for 1b, 1c, 2)
a. size
b. shape
c. color
d. other _____

Justification

1. No justification

2. Irrelevant justification _____

_____

3. Relevant justification _____

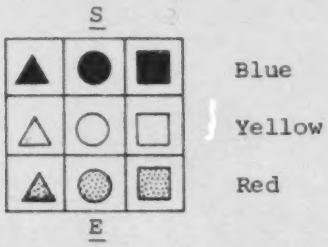
_____

*This format was used to score all sorts, the only change being in the designation of the sort as first, second, third, etc.

Cross Classification

MATERIALS

For this task the blocks are placed on the board in the following positions:



From where the child is sitting, red is on top, yellow in the middle, and blue on the bottom. Squares are at the left, circles in the center, and triangles at the right.

WARM-UP

The examiner places the nine blocks on the table and says, "Tell me what you see here." If the child does not spontaneously give the attributes, "triangle," "circle," "square" the examiner asks what shapes she/he sees. If the child does not spontaneously give the attributes "red," "yellow," "blue" the examiner asks what colors she/he sees.

The examiner then says, "Now I am going to put the blocks on this board in a special way. Look very carefully at how the blocks go." She/he places the blocks on the board in the following order: blue triangle, yellow triangle, red triangle, blue circle, yellow circle, red circle, blue square, yellow square, red square.

REPLACEMENT

The examiner says, "Now I am going to take away <u>one</u> block and I want you to put it back so that the board looks just the same as it does right now." These directions may be repeated in order to ensure

that the child realizes what is expected of him/her. If the child tends to watch the examiner while listening to the directions, she/he is asked to watch the board carefully before the examiner removes the block. The examiner then removes one block (randomly selected), puts it on the table near the child and says, "Now you put this block back where it belongs." When the child has finished the examiner says, "Now I am going to take away two blocks and I want you to put them back so the board looks just the same as it does right now." The examiner then removes two adjacent blocks (randomly selected) and says, "Now you put these back where they belong." When the child has finished the examiner says, "Now I am going to take away three blocks and I want you to put them back so the board looks just the same as it does right now." The examiner then removes the blocks on one of the diagonals and says, "Now you put these back where they belong."

REPRODUCTION

The examiner says, "This time I am going to take all of the blocks off the board and I want you to put them back so the board looks just the same as it does right now. Look at the board very carefully so you can remember just what it looks like. Look carefully and tell me when you're ready." When the child says she/he is ready the examiner removes the blocks, mixes them and says, "Now I want you to put the blocks back so that the board looks just the same as it did before."

TRANSPOSITION

The examiner says, "This time I am going to take all of the blocks off the board again. Then I am going to put one back, but it will be in a different place. I want you to put the blocks back so they make a

pattern (design) like this one. Now, look at the board again very carefully so you can remember just what it looks like. "Look carefully and tell me when you're ready." When the child says she/he is ready the examiner removes all of the blocks, mixes them and places the bottom left-hand block (blue square) at the top left-hand corner. The examiner then says, "Now you put all these blocks back on the board so they make a pattern (design) like they did before. Remember, this one must stay right here." If the child lifts the blue square, she/he is reminded that it is to stay in its place.

GENERAL

The child is always reassured about his/her performance whether she/he replaces all the objects correctly or not. If at any time the child replaces the blocks incorrectly, they are placed correctly by the examiner before proceeding to the next task. However, when this happens E reassures the child that she/he is doing well and explains that she/he (E) is arranging the blocks for the next game. After the warm-up, the examiner never mentions the color or shape of any of the blocks.

Cross Classification Time _____

Replacement

One block

a. placed correctly

b. other _____

_____

Two blocks

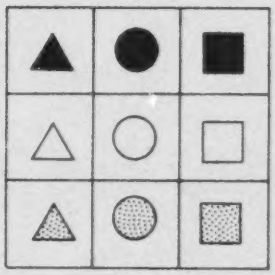
a. placed correctly

b. placed in reversed order

c. other _____

_____

S



E

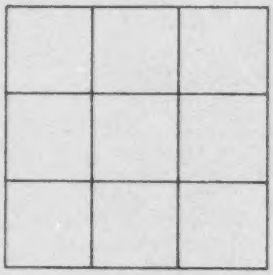
Three blocks

a. placed correctly

b. other _____

_____

S



E

Reproduction

Color

a. identical

b. transposed (indicate)

c. inconsistent (draw)

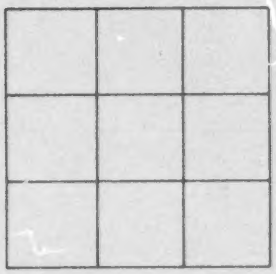
Shape

a. identical

b. transposed (indicate)

c. inconsistent (draw)

S



E

Transposition

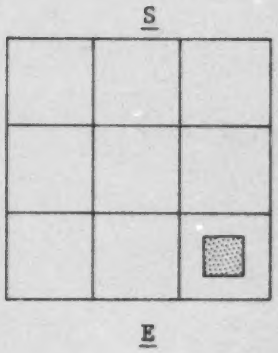
Color

a. identical
b. transposed (indicate)
c. inconsistent (draw)

B	B	R
Y	Y	Y
R	R	B

B	R	R
Y	Y	Y
R	B	B

B	B	Y
Y	Y	R
R	R	B



Shape

a. identical
b. transposed (indicate)
c. inconsistent

Class Inclusion

WARM UP

The examiner explains, "Here are some paper circles. Let's pretend they're chocolate chip cookies." E gives eight cookies to the child and keeps four cookies (the cookies are laid out one next to the other in two parallel rows) explaining, "Here are eight cookies for you and four cookies for me." E asks "Do we both have the same number of cookies? Do you have more cookies?" E puts away the "chocolate chip" cookies and takes out a second set of cookies explaining, "Here are some more pretend cookies. Let's pretend these are sugar cookies." E gives six cookies to the child and keeps six explaining, "Here are six cookies for you and six cookies for me." E asks, "Do we both have the same number of cookies? Do you have more cookies?"

TASK

E shows the child six boy dolls and three girl dolls explaining, "Here are some boy dolls and some girl dolls." E asks, "Are they all children?" After E has established with the child that all the dolls are children, she/he says, "Count all the children." If the child does not quickly begin to count, or counts incorrectly, E says, "Let's count them together" and has the child count with him/her. When the child has finished counting, the examiner repeats, "Right, there are nine children." Following this procedure, E asks the child to "Count the boys; count the girls." When the task is completed E asks the following (randomly ordered) questions:

a. Are there the same number of boys as children?

b. Are there more boys than children?

c. Are there more children than boys?

Each question may be repeated two or three times.

Class Inclusion

Name _____
School _____
Date _____
Tester _____
Scorer _____
Time _____

Chocolate Chip Cookies

"Here are eight cookies for you and four cookies for me."

"Do we have the same number of cookies?"

Yes No

"Do you have more cookies?"

Yes No

Sugar Cookies

"Here are six cookies for you and six cookies for me."

"Do we have the same number of cookies?"

Yes No

"Do you have more cookies?"

Yes No

"Count the children"

1. Counts by self
   a. Correct
   b. Incorrect
2. Needs help with counting

"Count the boys"

1. Counts by self
   a. Correct
   b. Incorrect
2. Needs help with counting

"Count the girls"

1. Counts by self
   a. Correct
   b. Incorrect
2. Needs help with counting

____ Are there the same number of boys as children?

1. Yes
2. No
3. Other _____

____ Are there more boys than children?

1. Yes
2. No
3. Other _____

____ Are there more children than boys?

1. Yes
2. No
3. Other _____

Time _____

Name _____
School _____
Date _____
Tester _____

Seriation Tasks

ABSOLUTE SERIATION

1. Two Blocks

Preparation:

E presents the two blocks (numbers 4, 5)* from the middle of the seriated set.

Explanation:

E explains, "Here are two blocks. Can you tell me which is the smallest block?"

Correct Incorrect

"Which is the biggest?"

Correct Incorrect

If the child fails to identify the correct blocks, E explains the correct choice and why. (Compare the two blocks.)

2. Seven Blocks

Preparation:

E presents an array of the largest 7 blocks (numbers 4, 5, 6, 7, 8, 9, 10)*

Explanation:

E explains, "Here are a lot of blocks. Which is the smallest block?"

Correct Incorrect

"Which is the biggest block?"

Correct Incorrect

*Block numbers refer to the position of blocks in a size-ordered series of 10, 1 indicating the smallest block.

Name _____
School _____
Date _____
Tester _____

RELATIVE SERIATION

Preparation:

E places 3 blocks (numbers 1, 2, 3) on the table, in order of size--smallest block to the child's right.

Explanation:

E explains, "Now we have three blocks." Pointing to the middle block, "Is this block bigger than any other block on the table?"

Yes No

"Which one is it bigger than?" (Point to it.)

Correct Incorrect

"Is this block smaller than any other block on the table?"

Yes No

"Which one is it smaller than?" (Point to it.)

Correct Incorrect

"Do you see a block here that is bigger than one block and smaller than another one?"

Yes No

"Show me which one is bigger than one block and smaller than another one."

Correct Incorrect

Name _____
School _____
Date _____
Tester _____

SUCCESSIVE SERIATION

Preparation:

E puts out 4 blocks (numbers 3, 4, 5, 6--smallest to the child's right) and builds a staircase, saying, "Look, here are some more blocks. We can make steps with them. See, I put the smallest one here, this one here, this one here and the biggest one here." (E uses fingers to demonstrate walking up the staircase.)

E then places seven of the seriated blocks (numbers 1, 2, 3, 4, 5, 6, 7) on the table in a random arrangement.

Explanation:

E explains, "Now we have lots of blocks. I want you to arrange these blocks in order from smallest to largest, so that they go up like the steps we just made. All of the blocks have to be in order."

If the child hesitates, ask him/her to find the smallest and place it to his/her right, then find the largest and place it to his/her left. "Now put all the other blocks in order between the biggest and the smallest to make the steps." (She/he must place the rest without help from E.)

Help required: Yes No

Number of blocks child places correctly:

1 2 3 4 5 6 7 (circle the number and show order below)

— — — — — — —

Name _____
School _____
Date _____
Tester _____

ADDITIVE SERIATION

Preparation:

E puts out ten blocks and says, "Now I'm making another staircase, but some steps are missing." E places seven blocks (1, 3, 4, 6, 8, 9, 10--smallest to the child's right) in sequence, with spaces between.

Explanation:

E places blocks number 2, 5, 7 (randomly arranged) near the child and says, "Here are three more blocks that go in the staircase. You put them into the staircase so that we still have stairs going from small at this end (child's right) to big at this end. Each block must go in so that it has a smaller block on one side and a bigger block on the other side, just like our other staircase.

If the child fails to get the idea, E places one of the blocks for him/her. After child has finished E asks, "Have you got them all the way you want them? Check and make sure."

Help necessary: Yes No

Number of blocks child places correctly:

1 2 3 (circle the number)

Name _____
School _____
Date _____
Tester _____

SERIAL CORRESPONDENCE

Preparation:

E places the lollipops in a seriated row on the table--smallest to the child's right. E then presents the child with the sticks in a mixed array, and talks about the materials and the seriation of the lollipops.

Explanation:

E explains, "These lollipops are lined up in order from the largest one to the smallest one (gesture). Now you line up the sticks in order from the largest one to the smallest one so that each one gets smaller as you go from here to here (gesture)."

Correct Incorrect_____
(indicate order)

E completes the task if necessary and says, "Now let's match each stick with its lollipop. I'll put the biggest stick with the biggest lollipop (place in one-to-one correspondence). Now you find the smallest stick and put it with the smallest lollipop. Now put each of these sticks with the lollipop that it goes with. (Find the right-sized lollipops to go with each stick.)"

Number placed correctly by the child:

1 2 3 4 5 (circle the number)

E completes the task if necessary and then extends the array of sticks so there is an extra stick at each end of the correspondence. E points to a single stick (chosen at random) and asks, "What lollipop goes with this stick? They have to be the right size for each other."

E repeats this procedure with three different sticks.

Correct Incorrect
Correct Incorrect
Correct Incorrect

E compresses sticks so there is an extra lollipop at each end of the correspondence. E points to a single stick (chosen at random) and asks, "What lollipop goes with this stick? They have to be the right size for each other."

E repeats this procedure with three different sticks.

Correct Incorrect
Correct Incorrect
Correct Incorrect

Time _____
Name _____
School _____
Date _____
Tester _____

Transitivity

WARM UP

E shows the child a picture of two perceptibly unequal parallel lines (10 cm and 20 cm respectively) and asks,

"Are the two lines the same length?"

Yes No No Response

"Which line is longer?"

Correct Incorrect No Response

"Which line is shorter?"

Correct Incorrect No Response

Name _____
School _____
Date _____
Tester _____

LENGTH

Materials: 28.5 cm red stick, 28.5 cm white stick,
27.5 red stick

Instructions:

E shows the child the three sticks to be used in the game and then places them to the side. E then places the long red stick and the white stick close together (vertically to E's right) so the child can observe that they are of equal length. E has the child verbalize that they are the same length. E leaves the long red stick in place and places the short red stick next to the white stick (to E's left, 15 inches from the long red stick) so the child can observe that the white stick is the longer of the two. E has the child verbalize the fact. E removes the white stick and asks the following (randomly ordered) questions:

_____ Are these two sticks the same length?

Yes No No Response

_____ Is one of the sticks longer? (If yes, which one is longer?)

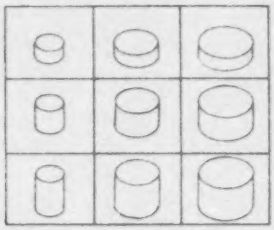
Yes: short/long No No Response

_____ Is one of the sticks shorter? (If yes, which one is shorter?)

Yes: short/long No No Response

Double Seriation

MATERIALS: For this task the blocks are placed on the board in the following positions:



From where the child is sitting, the tall blocks are on the top, the medium height blocks are in the middle, and the short blocks are on the bottom. Wide blocks are at his/her left, the medium width blocks are in the center, and the narrow blocks are at the right.

WARM UP

The examiner places the nine blocks on the table and says, "Tell me what you see here." If the child does not spontaneously mention the different heights, the examiner points to blocks differing in height (but not width) and asks how they are different. If the child does not spontaneously mention the different heights, the examiner points to blocks differing in width (but not height), and asks how they are different. (If the child hesitates, the examiner may provide him/her with the words "skinny" and "fat.")

The examiner then says, "Now I am going to put the blocks on this board in a special way. Look very carefully at how the blocks go." She/he then places the blocks on the board in the following order: S-1, S-2, S-3, M-1, M-2, M-3, F-1, F-2, F-3.*

*S designates skinny cylinder
M designates medium width cylinder
F designates fat cylinder
The numbers 1, 2, and 3 refer to the heights of the cylinders

REPLACEMENT

The examiner says, "Now I am going to take away one block and I want you to put it back so that the board looks just the same as it does right now." These directions may be repeated in order to ensure that the child realizes what is expected of him/her. If the child tends to watch the examiner while listening to the directions, she/he is asked to watch the board carefully before the examiner removes the block. The examiner then removes one block (randomly selected), puts it on the table near the child and says, "Now you put this block back where it belongs." When the child has finished the examiner says, "Now I am going to take away two blocks and I want you to put them back so the board looks just the same as it does right now." The examiner then removes two adjacent blocks (randomly selected) and says, "Now you put these back where they belong." When the child has finished the examiner says, "Now I am going to take away three blocks and I want you to put them back so the board looks just the same as it does right now." The examiner then removes the blocks on one of the diagonals and says, "Now you put these back where they belong."

REPRODUCTION

The examiner says, "This time I am going to take all the blocks off the board and I want you to put them back so the board looks just the same as it does right now. Look at the board very carefully so you can remember just what it looks like. Look carefully and tell me when you're ready." When the child says she/he is ready the examiner removes the blocks, mixes them and says, "Now I want you to put the blocks back so that the board looks just the same as it did before."

TRANSPOSITION

The examiner says, "This time I am going to take all of the blocks off of the board again. Then I am going to put one back, but it will be in a different place. I want you to put the blocks back so they make a pattern (design) like this one. Now, look at the board very carefully so you can remember just what it looks like. Look carefully and tell me when you're ready." When the child says she/he is ready the examiner removes all the blocks, mixes them and places the bottom left-hand block (F-1) at the top left-hand corner. The examiner then says, "Now you put all these blocks back on the board so they make a pattern (design) like they did before. Remember, this one must stay right here." If the child lifts block F-1, she/he is reminded that it is to stay in its place.

GENERAL

The child is always reassured about his/her performance whether she/he replaces all the objects correctly or not. If at any time the child replaces the blocks incorrectly, they are placed correctly by the examiner before proceeding to the next task. However, when this happens E reassures the child that she/he is doing well and explains that she/he (E) is arranging the blocks for the next game. After the warm up, the examiner never mentions the height or width of any of the blocks.

Name _____
School _____
Date _____
Tester _____

Double Seriation

Replacement
- One block
  - a. placed correctly
  - b. other _____
- Two blocks
  - a. placed correctly
  - b. placed in reversed order
  - c. other _____
- Three blocks
  - a. placed correctly
  - b. other _____

S

S-1	M-1	F-1
S-2	M-2	F-2
S-3	M-3	F-3

E
S

E
S

Reproduction
- Width
  - a. identical
  - b. transposed (indicate)
  - c. inconsistent (draw)
- Height
  - a. identical
  - b. transposed (indicate)
  - c. inconsistent (draw)

E
S

Transposition
- Width
  - a. identical
  - b. transposed (indicate)
  - c. inconsistent (draw)
- Height
  - a. identical
  - b. transposed (indicate)
  - c. inconsistent (draw)

		F-1

E

d.

1	3	3
2	2	2
3	1	1

1	1	3
2	2	2
3	3	1

e.

1	1	2
2	2	3
3	3	1

Name _____
School _____
Age _____
Date _____
Score _____
Tester _____

Spontaneous Measurement Tasks

LENGTH COMPARISON (LC)

Materials: 2 pencils of nearly the same length, one red and one blue

Pattern: Pencils placed at right angles and some distance apart on table top

Procedure: E talks about pencils (identifies them, talks about colors, etc.)
E asks, "Find out which of these pencils is longer, the red one or the blue one."

Response:

Process	Resulting Choice
___ a. direct visual estimate, other	___ a. incorrect
____ b. picks up pencil to compare	____ b. correct

If response is (a), E asks, "What could you do to make sure?" (Show me.)

Response: a. ____ picks up pencil to compare
b. ____ no measurement response
c. ___ other, not transition (describe); or
____ other, transition (describe)

Name _____
School _____
Age _____
Date _____
Score _____
Tester _____

DISTANCE VIA REFERENCE LENGTH (DRL)

Materials: Board with 2 black lines forming an angle
3 buildings: 1 "school" at the vertex of the angle
1 "house" fixed to the line
1 "house" for the child to manipulate
1 wooden stick the length of the distance from the fixed "house" to the "school"

Display: Board flat on table with wooden stick beside it
Small "house" to give to child

Procedure: E says, "In this game, all these things are for us to use if we want to (indicates everything on table). Here's a stick and this is a school (places school at vertex of angle) and this is my house (places it on the line). I walk this far to school. Here is a house for you (gives child house). Put your house on the line so you have just as far to walk to school as I do (indicates which line to put the house on)."

Response:

Process	Resulting Choice
____ a. simple placement	____ a. incorrect
____ b. measures with stick	____ b. correct

If process response is (a), E asks, "What could you do to make sure?" or "Can you show me how you could tell for sure?"

Response: (no score)
a.____ measures with stick
b.____ measures by eye or by running finger over line
c.____ no evidence of distance measurement; or
____ other, not transition (describe)
d.____ other, transition (e.g., uses a ruler)
e.____ relates to end of line

Name _____
School _____
Age _____
Date _____
Score _____
Tester _____

DISTANCE VIA UNITS (DU)

Materials: Board with lines and houses similar to DRL test
Small house for child
4 small rectangles whose combined length equals the distance from the school to the fixed house

Display: Board flat on table with rectangles nearby
Small house to give to child

Procedure: E says, "We can use anything on the table for this game, too. Here are some blocks. Here is a toy store and here is my house (indicates and places respective buildings). This is a house for you. Put your house on this line so you will have just as far to go to the store as I do."

Response:

Process	Resulting Choice
____ a. simple placement	____ a. incorrect
____ b. measuring with rectangles	____ b. correct

If process response is (a), E asks, "What could you do to make sure?"

Response: (no score)
a. ____ measures with rectangles*
b. ____ measures by running eye or finger over line
c. ____ no evidence of measurement; or
____ other, not transition (describe)
d. ____ other, transition (describe)
e. ____ relates to end of line

*If measures one side with rectangles but not other, circle the "a" (e.g., ⓐ).

Name _____
School _____
Age _____
Date _____
Score _____
Tester _____

HEIGHT VIA REFERENCE LENGTH (HRL)

Materials: 4 rectangular blocks painted to look like houses and varying in height by 1/4" steps
1 similar block equal in height to 1 of the other 4
1 plastic ladder the height of the standard block

Display: Ladder leaning on standard block
4 other blocks set up in irregular sequence

Procedure: E says, "We have some different houses and we have a ladder. And look! This ladder reaches just to the top of this house (yellow block). See if you can find another house that is just as high as this one."

Response:

Process	Resulting Choice
____ a. simply picks one	____ a. incorrect
____ b. measures with ladder	____ b. correct
____ c. direct comparison	
____ d. both (b) and (c)	

If process response is (a), E asks, "What could you do to make sure?"

Response: a. ____ measuring response--ladder
b. ____ uses ladder, but incorrect house
c. ____ compares houses
d. ____ uses ladder and compares houses
e. ____ no measuring response; or
____ other (describe)

Name _____
School _____
Age _____
Date _____
Score _____
Tester _____

AREA VIA UNITS (AU)

Materials: 2 brown rectangular configurations representing chocolate--1 divided into 8 squares of equal dimensions, the other into 9 squares each the same size as the squares in the first rectangle.

Display: Configurations set out on table

Procedure: E says, "Here are two pieces of cardboard. Let's pretend they're chocolate. See if you can find which one has more chocolate to eat."

Response:

Process	Resulting Choice
____ a. simply picks one	____ a. incorrect
____ b. counts squares	____ b. correct
____ c. compares 2 pieces superimposed	

If response is (a), E asks, "What could you do to make sure?"

Response: a. ____ compares 2 pieces superimposed

b. ____ counts squares

c. ____ no measurement response; or

____ other, not transition (describe)

d. ____ places side by side to compare

Name _____
School _____
Date _____
Tester _____

Conservation Tasks

WARM-UP

Number:

E constructs two parallel rows of evenly spaced chips (10 chips in the row closest to E, 3 chips in the row closest to the child) and asks,

"Do the two rows have the same number of chips?"

Yes No No Response

"Which row has more chips?"

Correct Incorrect No Response

"Which row has less chips?"

Correct Incorrect No Response

Length:

E then shows the child a picture of two unequal parallel lines (10 cm and 20 cm) and asks,

"Are the two lines the same length?"

Yes No No Response

"Which line is longer?"

Correct Incorrect No Response

"Which line is shorter?"

Correct Incorrect No Response

Substance:

E then hands the child two balls of play dough (one twice as large as the other) and asks,

"Do the two balls have the same amount of play dough?"

Yes No No Response

"Which ball has more play dough?"

Correct Incorrect No Response

"Which ball has less play dough?"

Correct Incorrect No Response

Name _____
School _____
Date _____
Tester _____

CONSERVATION OF NUMBER

Materials: 24 plastic chips

Introduction:

E constructs two parallel rows (twelve chips per row) of evenly spaced chips in the center of the table, making precise perceptual correspondence between the elements of the two rows. E discusses how the rows have the same number of chips. After the child has agreed that they have the same number of chips, E asks the following questions in random order:

Prediction:

____ "If I were to push the chips in this row (pointing to the row nearest to E) very close together, would the two rows still have the same number of chips?"

Yes No No Response

____ "If I were to push the chips in this row (indicating the same row) very close together, would one of the rows have more chips?"

Yes No No Response

____ "If I were to push the chips in this row (indicating the same row) very close together, would one of the rows have less chips?"

Yes No No Response

Deformation:

E pushes the chips in the row nearest to her/him together until they touch. E then asks the following questions in random order:

____ "Do the rows have the same number of chips?"

Yes No No Response

____ "Does one of the rows have more chips?"

Yes No No Response

____ "Does one of the rows have less chips?"

Yes No No Response

After the third question E asks, "How do you know that?"

Name _____
School _____
Date _____
Tester _____

CONSERVATION OF LENGTH

Materials: Two 28.0 cm lengths of string

Introduction:

E places the two lengths of string side by side and discuss how they are the same length. After the child agrees that they are the same length E asks the following questions in random order:

Prediction:

____ "If I were to make this string (to E's left) into a circle, would the two strings still be the same length?:

Yes No No Response

____ "If I were to make this string (to E's left) into a circle, would one of the strings be longer?"

Yes No No Response

____ "If I were to make this string (to E's left) into a circle, would one of the strings be shorter?"

Yes No No Response

Deformation:

E then transforms one of the strings (to E's left) into a circle and asks the following questions in random order:

____ "Are the two pieces of string the same length?'

Yes No No Response

____ "Is one of the pieces of string longer?"

Yes No No Response

____ "Is one of the pieces of string shorter?"

Yes No No Response

After the third question E asks, "How do you know that?"

Name _____
School _____
Date _____
Tester _____

CONSERVATION OF SUBSTANCE

Materials: 2 identical play dough balls

Introduction:

E shows the child the two balls and discusses how they contain the same amount of play dough. After the child has agreed that they have the same amount of play dough E asks the following questions in random order:

Prediction:

____ "If I were to flatten this ball (to E's left) into a "pancake," would they still have the same amount of play dough?"

Yes No No Response

____ "If I were to flatten this ball (to E's left) into a "pancake," would one of them have more play dough?"

Yes No No Response

____ "If I were to flatten this ball (to E's left) into a "pancake," would one of them have less play dough?"

Yes No No Response

Deformation:

E flattens one of the balls (to his left) into a "pancake" and asks the following questions in random order:

____ "Do the two pieces have the same amount of play dough?"

Yes No No Response

____ "Does one of these have more play dough?"

Yes No No Response

____ "Does one of these have less play dough?"

Yes No No Response

After the third question E asks, "How do you know that?"

Stage Designation Explanations by Task.

The phrases opposite each stage designation correspond to patterns of response for the questions in each task. Refer to the protocols above for clarification.

Task	Stage	Actual Response	Explanation
Dichotomous sorting	III	3 different sorts	sorts consistently on self chosen criteria and exhausts all possible criteria
	II_b	2 different sorts	sorts consistently but does not use all possible criteria
	II_a	1 sort	
	I	no sorts	no dichotomous sorts
Cross classification			
reproduction	III	2 a's; or 1 (b); or 2 (b)'s	entire matrix correct
	II_b	1a and 1b; or 2b's	1-2 mistakes in which 2 adjacent blocks are switched
	II_a	1c	inconsistency in shape or color
	I	2c's	inconsistency in shape and color

Task	Stage	Actual Response	Explanation
transposition	III	2a's; or (b),a; or (b),(b); or a,(b)	entire matrix correct
	II_b	1d; or 1e; or a,b; or b,a; or (b),b; or b,b	essence of matrix is preserved but 1-2 mistakes are made involving the switching of adjacent blocks or a change in direction of one row or column
	II_a	1c	inconsistency in either shapes or color
	I	2c's	inconsistency in shape and color
Class inclusion	III	No, No, Yes	3 correct responses
	II	Yes, No, Yes; or No, Yes, Yes; or No, No, No	1 incorrect response
	I	Yes, Yes, Yes; or No, Yes, No; or Yes, No, No; or Yes, Yes, No	2-3 incorrect responses
Seriation			
(a) absolute seriation	III	4C	all correct
	II	3C	1 incorrect response
	I	0-2C	2 or more incorrect responses
(b) relative seriation	III	Yes-C, Yes-C, Yes-C for questions 5 & 6	

Task	Stage	Actual Response	Explanation
(b) relative seriation (cont.)	II_b	No-C; or Yes-C for questions 5 & 6	more correct than incorrect and questions 5 and 6 as designated
	II_a	Yes-I; or No-I for questions 5 & 6	
	I	No-I, No-I, No-I; or Yes-I, Yes-I, Yes-I; or C	more incorrect than correct
(c) successive seriation	III	No & 7 blocks correctly placed	count only blocks in successive order with no skips
	II_c	Yes & 6 blocks correctly placed; or No & 6 blocks correctly placed	places 1 block incorrectly or needs help initially
	II_b	Yes & 5 blocks correctly placed; or No & 5 blocks correctly placed	made 2 mistakes or made 1 mistake and needed help
	II_a	Yes & 4 blocks correctly placed; or No & 4 blocks correctly placed	made 3 mistakes or made 2 mistakes and needed help
	I	Yes & 1-3 blocks correctly placed; or No & 1-3 blocks correctly placed	made 4 mistakes or made 2 mistakes and needed help
(d) additive seriation	III	No & 3 blocks correctly inserted	All blocks inserted correctly
	II_b	Yes & 2 blocks correctly inserted; or No & 2 blocks correctly inserted	made one mistake or made no mistakes and needed help
	II_a	Yes & 1 block correctly inserted; or No & 1 block correctly inserted	made 2 mistakes or made 1 mistake and needed help
	I	Yes & no blocks correctly inserted; or No & no blocks correctly inserted	made 3 mistakes or made 2 mistakes and needed help

Task	Stage	Actual Response	Explanation
(e) serial correspondence 1-warm-up question (scored as for successive seriation)	III	7 blocks ordered successively	made no mistakes
	II_c	6 blocks ordered successively	made 1 mistake
	II_b	5 blocks ordered successively	made 2 mistakes
	II_a	4 blocks ordered successively	made 3 mistakes
	I	0-2 blocks ordered successively	made 4 or more mistakes
questions 3 & 4 (question 2 was omitted from analysis)	III	6 correct pairs	made no mistakes
	II_b	4 or 5 correct pairs	made 1 or 2 mistakes
	II_a	3 correct pairs	made 3 mistakes
	I	0-2 correct pairs	made 4 or more mistakes
Double seriation			
reproduction	III	a,a; or (b),(b); or a,(b); or (b),a	entire matrix correct
	II_b	b,a; or a,b	one mistake--2 adjacent blocks switched
	II_a	one c; or 2b's	1 inconsistency or 2 mistakes--two adjacent blocks switched
	I	2c's	2 inconsistencies
transposition	III	a,a; or (b),a; or a,(b); or (b),(b); or one e; or one d; or b,a; or a,b	entire matrix correct

Task	Stage	Actual Response	Explanation
	II_b	1e; or 1d; or b,a; or a,b	essence of matrix is preserved but 1-2 mistakes are made by switching adjacent blocks or by changing direction of one row or column
	II_a	1c	inconsistency in either shape or color
	I	2c's	inconsistency in shape and color
Transitivity	III	No, yes-long, yes-short	all correct
	II_c	Yes, yes-long, yes-short	first question incorrect and both processes correct
	II_b	No, one process combination incorrect	first question correct and one process combination incorrect
	II_a	Yes, one combination incorrect	first question incorrect and one process combination incorrect
	I	Yes, both combinations incorrect; or No, both combinations incorrect	both process combinations incorrect

Spontaneous measurement		Process/Choice/Response			
(a) length comparison	III	a	b	--; or	makes a correct
		a	b	a*	direct comparison
	II_b	b	a	a or (c);	incorrect judgment
		a	b	or (c)	with spontaneous measuring response or correct judgment with a provoked measuring response

Spontaneous measurement		Process/Choice/Response			
	II_a	a	a	a or c	provoked measuring response after an incorrect choice
	I	a	a or b	b or c	no measuring response

Task	Stage	Process/Choice/Response			Explanation
(b) distance via reference length	III	b a	b b	--; or a*	makes correct judgment and uses stick to measure
	II_b	b	a	a or d	incorrect judgment with spontaneous measuring response
	II_a	a	a	a or d or (a)	provoked measuring response after an incorrect choice
	I	a	a or b	b or c or e	no measuring response
(c) distance via units	III	b a	b b	--; or a*	makes correct judgment and uses repeated units to measure
	II_c	b	a	a or d or (a)	incorrect judgment with spontaneous measuring response
	II_b	a	b	d or (a)	correct judgment and incomplete measuring response
	II_a	a	a or b	a or d or (a)	incorrect judgment with a provoked measurement response
	I	a	a or b	b or c or e	no measuring response

*an asterisk is used with the stage designation to indicate the particular response pattern as indicated.

Task	Stage	Process/Choice/Response			Explanation
(d) height via reference length	III	b or c or d	b	--; or a or b or c or d	makes correct choice and measures either by direct comparison or by a reference ladder
		a	b		
	II_b	b or c or d	a	a or b or c or d	incorrect choice with both spontaneous and provoked measuring responses
			a		
	II_a	a	a	a or b or c or d; or e; or e	incorrect choice with a single measuring response (either provoked or spontaneous but not both)
		b	a		
		c or d	a		
	I	a	a or b	e or a	no measuring response
(e) area via units	III	a or b or c	b	a or b or --	makes correct comparison
	II_b	a or d	a	a or b or c	incorrect judgment with spontaneous measurement response
	II_a	a or d	a	a or b or (c)	incorrect judgment with provoked measurement response
	I	a	a or b	c or d	no measurement response
Conservation[+]	III	Yes, No, No			all correct responses
	II	Yes, No, Yes; or No, No, No; or Yes, Yes, No			1 incorrect response
	I	No, Yes, Yes; or No, No, Yes; or No, Yes, No; or Yes, Yes, Yes			2 or 3 incorrect responses

[+]Substance, length, and number were each scored identically; prediction and deformation were scored separately; justifications were recorded as R - relevant, I - irrelevant, (I) - for length only when child's response indicated a misunderstanding of the question.

Material needed for testing

Peabody Picture Vocabulary Test by Lloyd M. Dunn, Ph.D.
American Guidance Service, Inc.
Publisher's Building
Circle Pines, Minnesota 55014

1. Series of plates
2. Score sheet
3. Manual

Raven - Distributed in the U.S. by
The Psychological Corp.
304 East 45th Street
New York, New York 10017

Prepared by J. C. Raven, M.S.
Director of Psychological Research
The Crichton Royal, Dumfries

1. Guide
2. Coloured Progressive Matrices
3. Score sheet

Classification I

Dichotomies

1. 22 blocks for sorting
2. Demonstration dolls
3. Score sheet

Classification II

Class Inclusion

1. 8 circles of brown construction paper (2-1/2" diameter)
2. 12 scalloped circles of light brown construction paper (2-1/2" diameter)
3. 9 paper dolls - 3 girls, 6 boys
4. Score sheet

Cross Classification

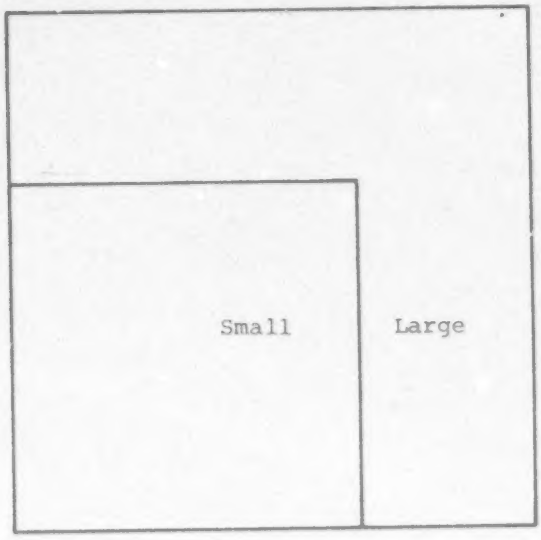
1. 1 board 14" x 14" x 1/2" plywood
2. 9 blocks 3 triangles - 1 blue - 1 yellow - 1 red
   3 circles - 1 blue - 1 yellow - 1 red
   3 squares - 1 blue - 1 yellow - 1 red
3. Score sheet

Counterbalance order of questions in class inclusion

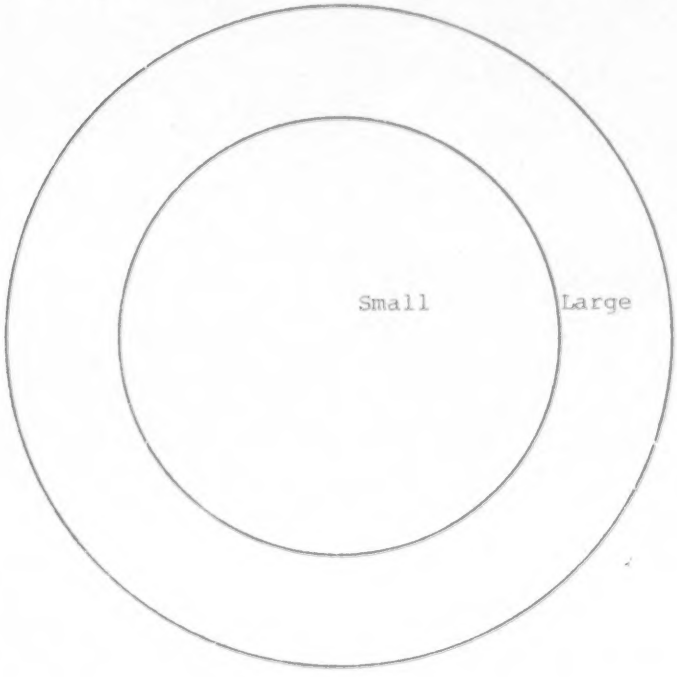
Classification

Dichotomies

1. 5 large square blocks - 3 red, 2 blue 3" x 3" x 7/16"
2. 6 small square blocks - 3 red, 3 blue 2" x 2" x 7/16"

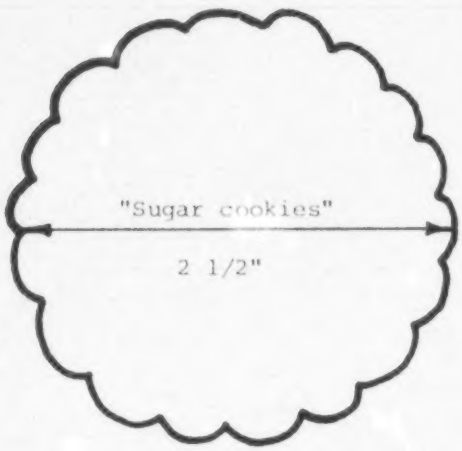


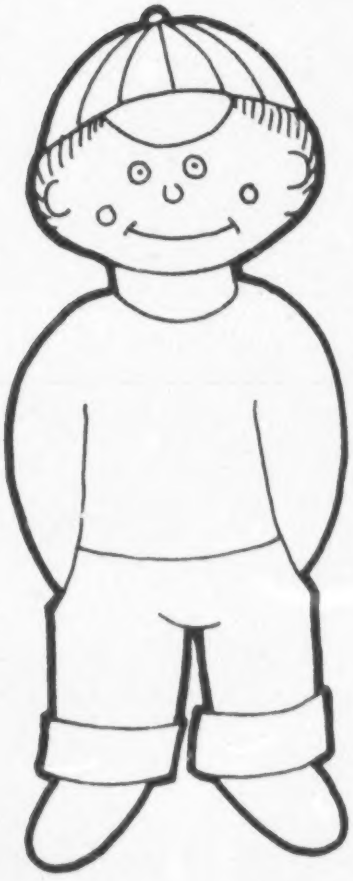
3. 5 large circles - 2 red, 3 blue 3-3/16" x 7/16"
4. 6 small circles - 3 red, 3 blue 2-1/2" x 7/16"

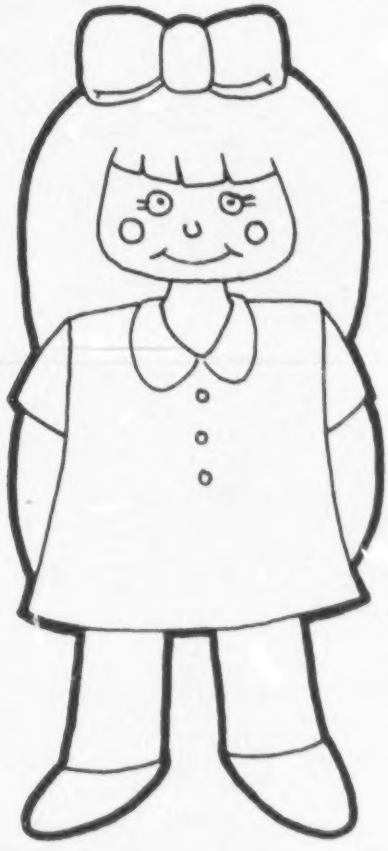


5. Demonstration dolls - 3 boys - 2 with flowers - 1 without
3 girls - 1 with flowers - 2 without

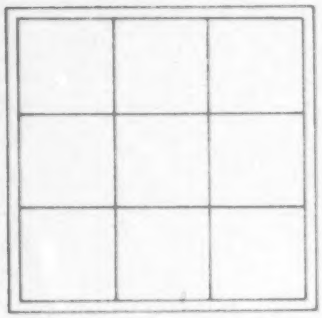
Class Inclusion





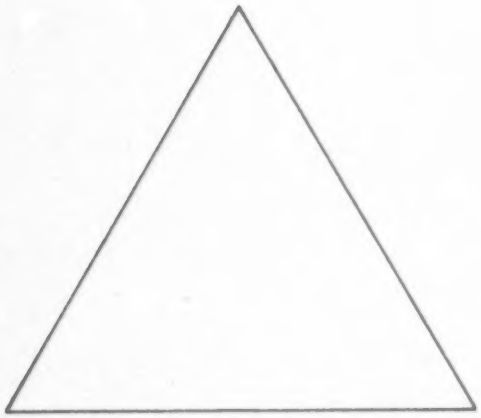


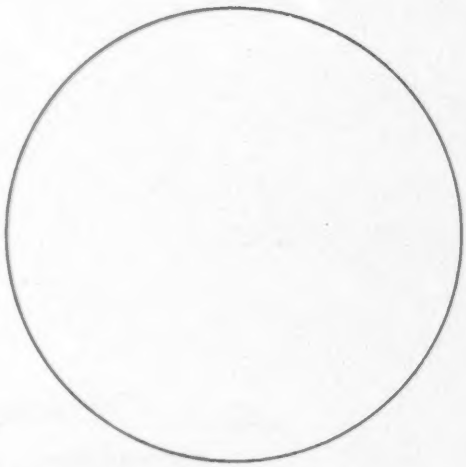
Cross Classification



3/4" Boarder

Each square is 4 1/8" x 4 1/8"





Blocks are 3/8" thick

Seriation I

1. Set of 10 Montessori blocks
2. Set of 7 cardboard lollipops
3. Score sheet

Seriation II

1. Transitivity

   a. Warm up
      1. 9" x 12" construction paper with 2 lines (10 cm and 20 cm respectively)

   b. Transitivity
      1. 15-1/2" x 17-1/8" heavy cardboard with 2 red sticks glued on it.
      2. 3 sticks - 1 red stick 28.5 cm
         1 red stick 27.5 cm
         1 white stick 28.5 cm

2. Double Seriation

   a. Same board as for Cross Classification
   b. 9 round blue blocks
   c. Score sheet

Counterbalance order of questions in transitivity.

Seriation: Montessori blocks

Absolute Comparison:	1 block 1-5/8" x 1-5/8" x 8"	#4	Part
	1 block 2" x 2" x 8"	#5	I
	1 block 2-3/8" x 2-3/8" x 8"	#6	
	1 block 2-3/4" x 2-3/4" x 8"	#7	Part
	1 block 3-1/4" x 3-1/4" x 8"	#8	II
	1 block 3-5/8" x 3-5/8" x 8"	#9	
	1 block 4" x 4" x 8"	#10	

Relative Comparison:	1 block 7/16" x 7/16" x 8"	#1
	1 block 13/16" x 13/16" x 8"	#2
	1 block 1-3/16" x 1-3/16" x 8"	#3

Successive Comparison:	1 block 1-3/16" x 1-3/16" x 8"	#3
	1 block 1-5/8" x 1-5/8" x 8"	#4
	1 block 2" x 2" x 8"	#5
	1 block 2-3/8" x 2-3/8" x 8"	#6

Additive Seriation: block numbers 1, 3, 4, 6, 8, 9, 10
2, 5, 7

Serial Correspondence

7 circles and 7 separate sticks

Largest 4" diameter
3-1/2"
3"
2-1/2"
2"
1-1/2"
1"

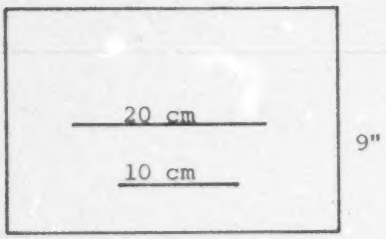
Longest 7-1/2" x 5/8"
6-1/2"
5-1/2"
4-1/2"
3-1/2"
2-5/8"
1-5/8"

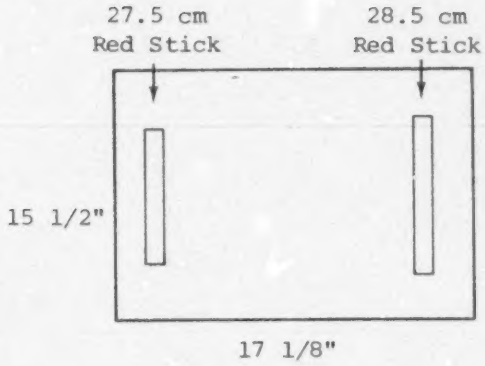
1	2	3	4	5	6	7

Seriation II

Transitivity

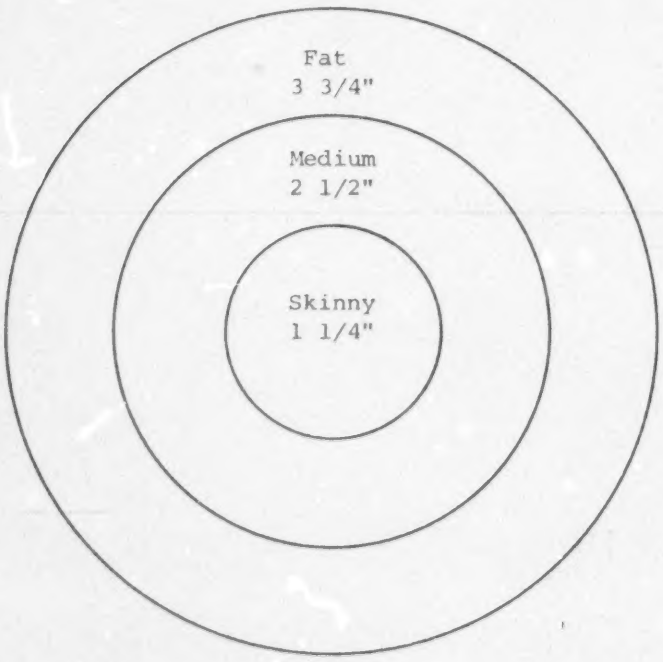
Warm Up

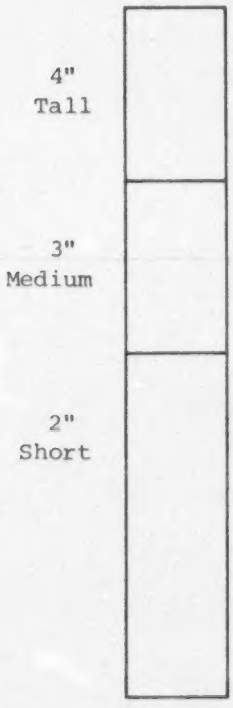




Sticks are glued on 1" from each edge.

Double Seriation Blocks





Measurement

Length Comparison

1. 2 sharpened pencils of nearly the same length, 1 red and 1 blue
2. 1 cardboard 22" x 13-3/4"

Distance via Reference Length

1. 1 cardboard 22" x 13-3/4"
   1 "School" block
   2 "House" blocks
   1 stick

Distance via Units

1. 1 cardboard 22" x 13-3/4"
   1 "Store" block
   2 "House" blocks } Different than previous set
   4 unit blocks all painted the same color

Height via Reference Length

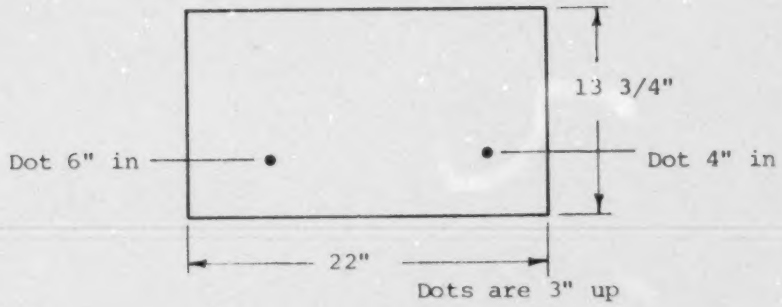
1. 4 white Houses
   1 yellow house for standard
   1 plastic ladder

Area via Units

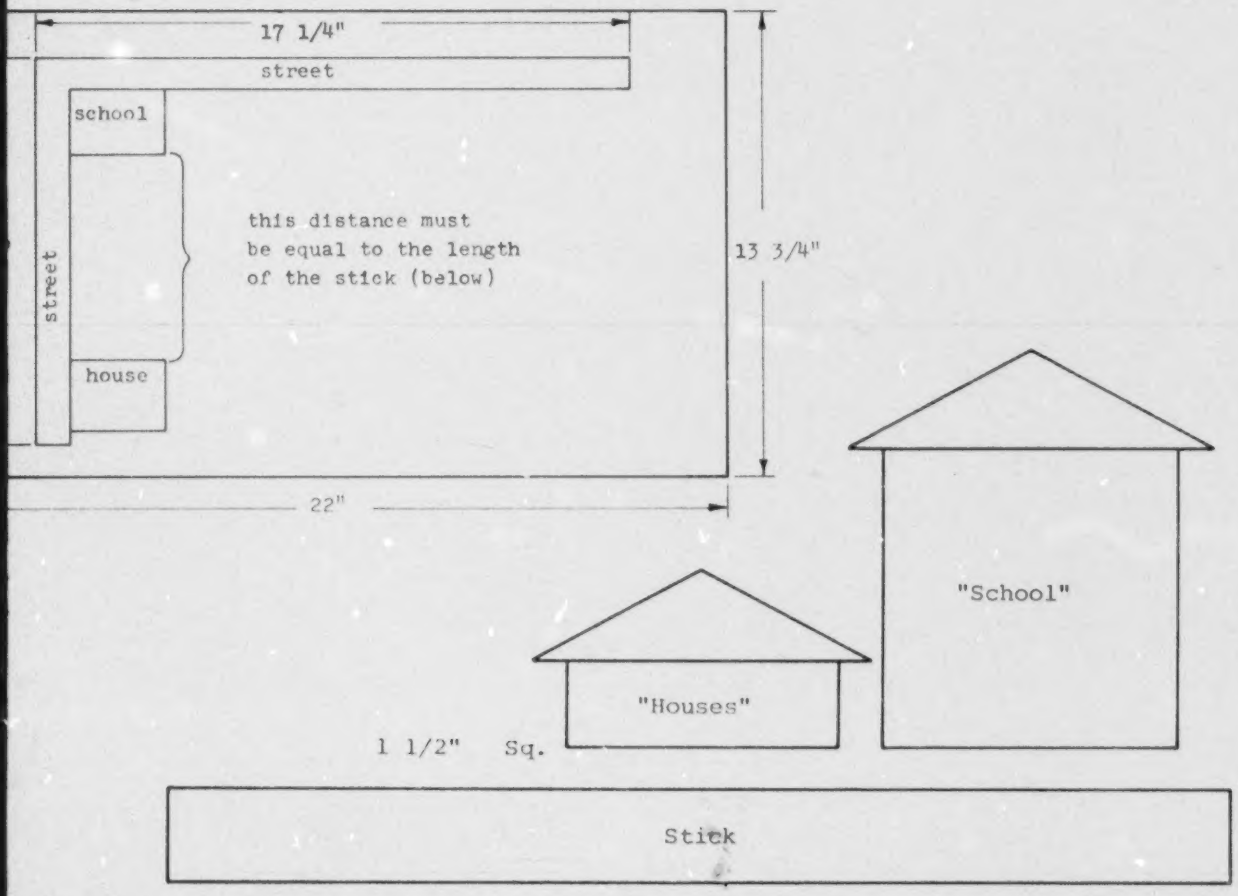
1. 2 cardboards covered with brown paper and marked off in squares

Measurement

Test A - Length Comparison

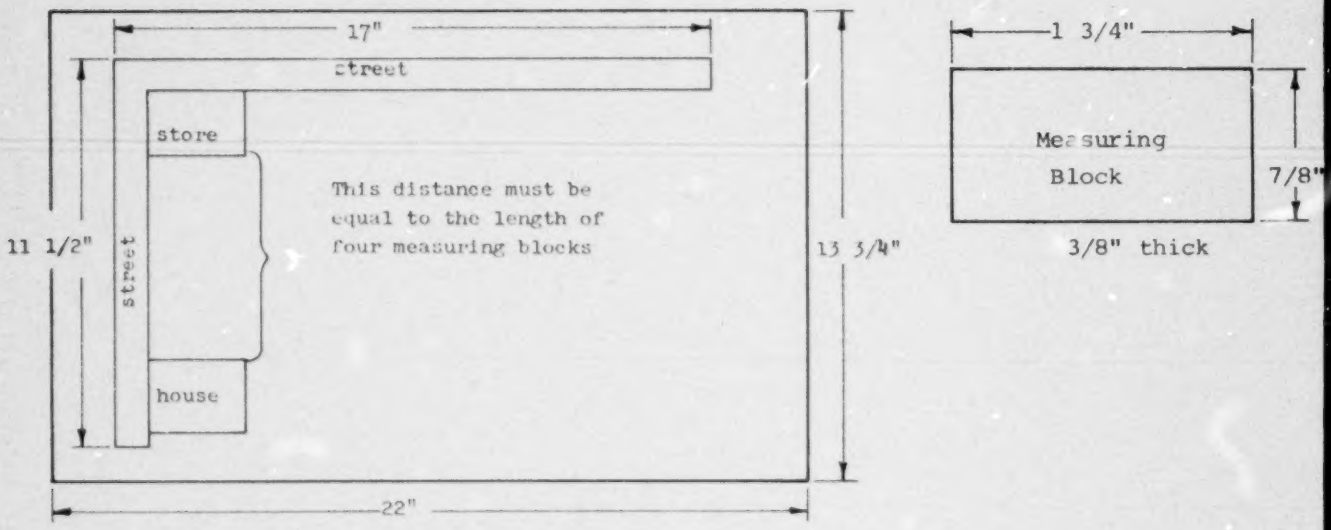


Test B - Distance via Reference Length



Test C - Distance via Units

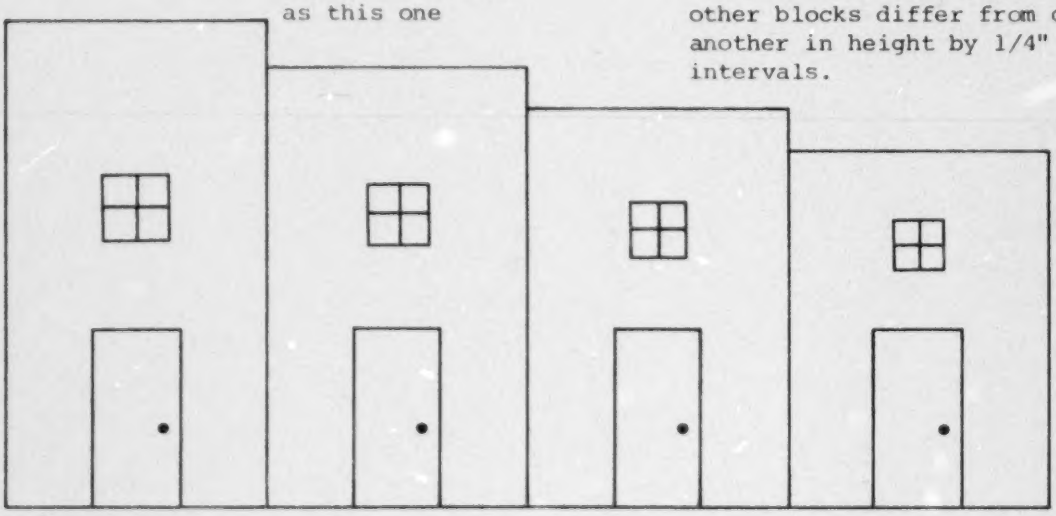
Store and house blocks are the same size as Test B, but painted differently.

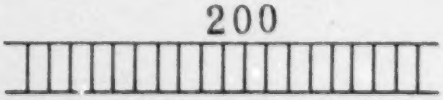


Test D - Height via Reference Length

Yellow Standard block same size as this one

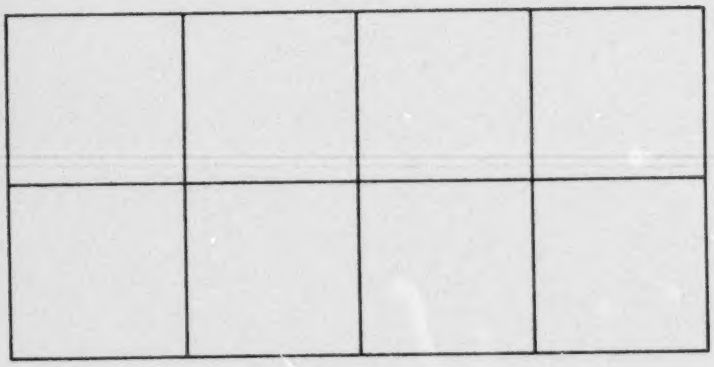
All blocks have a 1 1/2" square base. Standard is 2 1/2" high; other blocks differ from one another in height by 1/4" intervals.

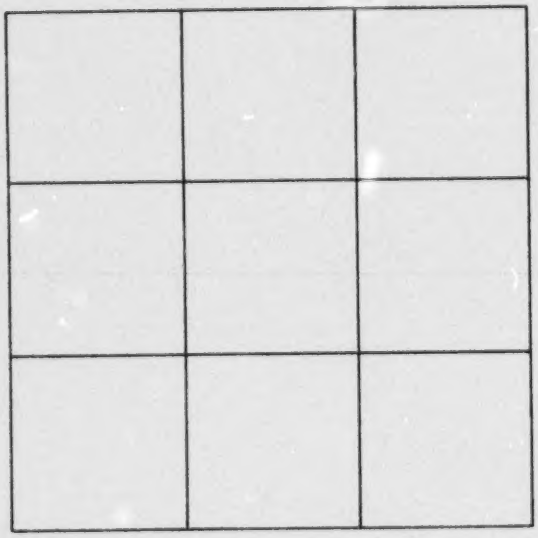




ladder: length equals the height of the standard block

Test E - Area via Units





Conservation

Warm up

1. 13 chips
2. 9" x 12" colored construction paper with 2 lines drawn on
3. Play dough (2 balls - 1 large, 1 small) same color

Conservation of Substance

1. Play dough (2 large balls, same color)

Conservation of Number

1. 24 plastic chips. Same color.

Conservation of Length

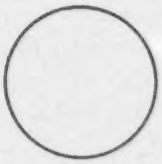
1. 2 - 28.0 cm of string

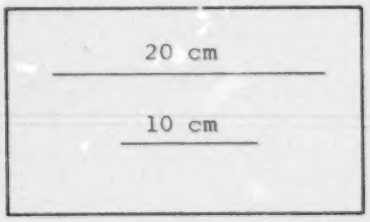
Counterbalance for order of presentation for each conservation task and for questions within a single task.

Conservation

Warm up

1. 13 chips, all same color
2. Picture lines





The 24 chips for number task should be a different color than the warm up chips.

Appendix C

Comprehensive Score Patterns and State Designations for Complete Task Battery

Raw Pretest Data Experimental Group: Wave I

Title	Age as of 10/1/71	Peabody	Raven	Dichotomies	Class Inclusion	Cross Class		Seriation				Seria Corre		Doubl Seria		Transitivity	Measurement					Conservation No.		Length		Subst	
						Repro	Transpo	Absolute	Relative	Successive	Additive	(1)	(3) & (4)	Repro	Transpo		Length Comparison	Distance via Reference Length	Distance via Units	Height via Reference Length	Area via Units	Prediction	Deformation	Prediction	Deformation	Prediction	Deformation
Burton	35	30	11	I	--	--	--	III	IIa	I	IIa	--	IIb	--	--	--	III	I	I	IIa	I	--	--	--	--	--	--
Andrew	35	34	11	I	--	--	--	III	IIa	I	I	--	I	--	--	--	I	I	I	I	I	--	--	--	--	--	--
Paul	47	39	18	IIa	--	--	--	III	IIa	I	IIa	--	I	--	--	--	III*	I	IIa	III	IIa	--	--	--	--	--	--
Michael	39	47	17	IIa	--	--	--	III	IIa	IIb	IIb	--	I	--	--	--	III*	I	I	III	IIa	--	--	--	--	--	--
Peter L	39	48	10	IIa	--	--	--	III	IIb	I	IIb	--	IIb	--	--	--	IIb	I	IIa	III	IIa	--	--	--	--	--	--
Stephen	46	47	18	IIa	--	--	--	III	IIa	IIb	IIb	--	I	--	--	--	III	I	I	I	I	--	--	--	--	--	--
John	44	38	14	I	--	--	--	III	IIa	IIa	III	--	IIa	--	--	--	III*	I	I	I	IIa	--	--	--	--	--	--
Darrell	43	12	15	I	--	--	--	I	I	I	I	--	IIa	--	--	--	I	I	I	IIa	I	--	--	--	--	--	--
Damon	38	24	--	I	--	--	--	III	IIa	I	I	--	I	--	--	--	I	I	I	I	III*	--	--	--	--	--	--
Steven	42	45	13	--	--	--	--	III	IIb	I	IIb	--	I	--	--	--	IIa	I	I	III	I	--	--	--	--	--	--
Barbara	42	47	14	IIa	--	--	--	III	IIa	I	IIa	--	I	--	--	--	III	I	I	III	I	--	--	--	--	--	--
Erica C	38	51	16	I	--	--	--	III	III	I	IIb	--	IIb	--	--	--	I	I	I	III	III*	--	--	--	--	--	--
Meira	41	41	19	IIa	--	--	--	III	IIa	IIb	I	--	I	--	--	--	I	I	I	III	I	--	--	--	--	--	--
Allison	36	46	15	I	--	--	--	III	IIa	IIa	I	--	I	--	--	--	I	IIa	IIa	III	I	--	--	--	--	--	--
Keira	37	39	--	IIa	--	--	--	III	IIa	IIb	I	--	IIb	--	--	--	I	I	I	III	IIa	--	--	--	--	--	--
Mayora	37	38	--	IIa	--	--	--	III	IIa	I	I	--	I	--	--	--	I	I	I	III	I	--	--	--	--	--	--
Erika K	43	50	--	IIa	--	--	--	III	IIa	I	I	--	IIb	--	--	--	III	I	I	III	I	--	--	--	--	--	--
Alicia	38	34	--	I	--	--	--	III	IIa	I	I	--	IIa	--	--	--	I	I	I	I	I	--	--	--	--	--	--
LaNicerra	38	21	--	I	--	--	--	I	IIa	I	I	--	IIb	--	--	--	I	I	I	I	IIa	--	--	--	--	--	--
LaQuetta	38	13	15	I	--	--	--	I	I	I	IIa	--	I	--	--	--	I	I	I	I	I	--	--	--	--	--	--

205

206

for the scoring system for each task

Raw Pretest Data: Experimental Group, Wave II

Name	Age as of 10/1/72	Peabody	Raven	Dichotomies	Class Inclusion	Cross Class		Seriation				Seri Corr		Double Ser		Transitivity	Measurement					Conservation					
																						Number		Length		Substance	
						Repro	Transpo	Absolute	Relative	Successive	Additive	(1)	(3) & (4)	Repro	Transpo		Length Comparison	Distance via Reference Length	Distance via Units Height via Reference Length		Area via Units	Prediction	Deformation	Prediction	Deformation	Prediction	Deformation
Thomas	41	48	12	IIa	I	III	IIa	III	I	IIb	I	IIa	IIb	I	I	IIa	I	I	I	IIa	I	I	I	I	I	I	I
Matthew	39	36	9	IIa	III	I	I	III	I	I	I	III	I	I	I	I	III*	I	I	IIb	I	II	II[I]	I	I	I	I
Andrew	38	39	10	I	II	I	I	III	IIa	I	IIb	IIc	IIb	I	I	I	I	I	I	I	I	I	I	I	II*[I]	I	I
Justin	40	50	12	IIa	I	I	I	III	IIa	I	I	III	I	I	I	III	IIa	I	I	III	IIb	I	I	I	I	I	I
Joel	41	48	9	I	III	IIb	I	III	I	I	I	I	IIa	I	I	IIc	I	I	I	III	I	I	I	II	I	I	I
Kurt	38	52	7	I	I	I	I	III	I	I	I	IIb	I	I	I	IIc	I	I	I	I	I	I	I	I	II*[I]	I	I
Chuck	45	38	11	I	I	I	I	I	IIa	I	I	I	IIb	I	IIa	I	I	I	I	III	I	I	I	I	II[I]	I	I
James	43	46	7	I	II*	I	IIa	III	I	IIb	IIa	IIc	IIb	I	I	I	I	I	I	III	I	I	I	II	I	II	I
Reid	41	43	14	IIa	I	IIa	I	III	IIa	IIa	IIb	I	I	I	I	I	IIa	I	I	IIa	I	I	I	I	I	I	I
Matt	46	49	10	I	I	IIa	IIb	III	I	IIb	IIb	IIb	III	I	I	IIc	III	I	I	III	I	I	I	II	I	I	I
Paul	40	36	14	IIa	I	IIa	IIa	III	IIa	IIb	IIa	IIa	IIb	IIa	IIa	IIc	I	I	I	IIa	IIb	I	I	I	I	I	I
Marguerite	34	24	10	I	II	IIa	I	II	IIb	IIb	IIa	I	I	I	I	IIa	I	I	I	III	I	I	I	II	I	I	I
Gail	38	41	8	IIa	I	I	I	III	I	I	I	I	IIa	I	I	IIc	I	I	I	III	I	I	I	I	I	I	I
Patricia	45	28	10	I	II*	I	I	I	IIb	I	I	IIb	IIb	I	I	I	I	I	I	I	I	I	II*[I]	II*	II*[I]	II*	II*[I]
Kathryn	40	68	11	IIa	I	IIa	IIb	III	IIa	IIa	I	IIa	IIb	I	I	I	I	I	I	III	I	I	II[I]	I	I	I	I
Amani	38	27	11	I	I	I	I	I	IIa	I	I	IIb	IIb	I	I	IIc	I	I	I	I	I	I	I	I	I	I	I
Tal	41	12	4	I	II*	I	I	I	IIb	IIb	IIa	IIa	IIb	I	I	I	I	I	I	III	I	I	I	I	I[I]	I	I
Caroline	42	41	16	IIa	I	IIa	IIb	III	III	I	III	III	III	I	IIa	I	I	I	I	III	I	I	I	I	II	III	III[I]
Wendy	44	38	14	I	I	I	I	III	I	I	IIa	IIa	IIa	I	I	I	IIa	I	I	IIa	I	I	II[I]	I	I	I	III[I]
Sarah	38	48	12	IIa	I	IIa	I	III	IIa	I	IIa	I	IIb	IIa	IIa	IIa	I	I	I	III	I	I	I	I	I	I	I
Louisa	38	29	9	IIa	II*	IIa	I	III	III	I	I	NR	IIb	I	I	I	I	I	I	IIa	I	I	I	I	I	I	I
Katrine	45	47	18	IIa	II	IIa	I	III	IIa	I	I	IIa	IIb	I	IIa	III	III*	I	I	III	IIa	II	I	I	I	I	I

Note: Consult the scoring procedures for the scoring range for each task.

Raw Pretest Data: Control Group, Wave I

Name	Age as of 10/1/71	Peabody	Raven	Dichotomies	Class Inclusion	Cross Class		Seriation				Serial Corr		Doubl Seria		Transitivity	Measurement					Conservation No.		Length		Subst.	
						Repro	Transpo	Absolute	Relative	Successive	Additive	(1)	(3) & (4)	Repro	Transpo		Length Comparison	Distance via Reference Length	Dist. via Units	Ht. via Ref. Len	Area via Units	Prediction	Deformation	Prediction	Deformation	Prediction	Deformation
Charles	41	53	10	IIa	--	--	--	III	IIa	I	I	--	I	--	--	--	I	I	I	III	I	--	--	--	--	--	--
Michael	37	45	11	IIa	--	--	--	III	IIa	I	IIa	--	I	--	--	--	I	I	I	I	I	--	--	--	--	--	--
Erik	49	38	15	IIa	--	--	--	III	IIb	IIa	IIa	--	IIb	--	--	--	III*	I	I	III	I	--	--	--	--	--	--
Roan	42	57	11	IIa	--	--	--	III	III	IIa	I	--	I	--	--	--	IIa	I	I	III	I	--	--	--	--	--	--
Matthew	48	47	--	IIa	--	--	--	III	IIa	I	IIa	--	I	--	--	--	I	I	I	I	I	--	--	--	--	--	--
Peter	47	54	--	I	--	--	--	III	IIa	I	IIb	--	IIb	--	--	--	I	I	I	III	IIa	--	--	--	--	--	--
Keven	42	54	--	III	--	--	--	III	IIa	I	IIa	--	IIb	--	--	--	III	I	I	III	III	--	--	--	--	--	--
Jimmy	39	52	--	IIa	--	--	--	III	IIa	I	IIa	--	IIa	--	--	--	I	I	I	III	I	--	--	--	--	--	--
Brian R	49	48	--	IIa	--	--	--	III	IIa	IIb	I	--	1	--	--	--	III*	I	I	III	I	--	--	--	--	--	--
Bryan S	47	56	--	IIa	--	--	--	III	IIa	IIb	IIa	--	IIa	--	--	--	IIa	I	I	III	IIa	--	--	--	--	--	--
Laura	37	48	14	IIa	--	--	--	III	IIa	IIb	III	--	IIa	--	--	--	I	I	I	III	I	--	--	--	--	--	--
Ann	48	59	11	I	--	--	--	III	IIa	I	I	--	IIb	--	--	--	I	I	I	I	III	--	--	--	--	--	--
Deborah	45	46	13	IIa	--	--	--	III	IIa	I	IIa	--	I	--	--	--	IIb	I	I	III	I	--	--	--	--	--	--
Jennifer	35	39	10	IIa	--	--	--	III	IIa	I	I	--	IIb	--	--	--	I	I	I	III	I	--	--	--	--	--	--
Kristin	47	52	--	IIb	--	--	--	III	III	I	IIb	--	I	--	--	--	I	I	I	III	I	--	--	--	--	--	--
Wendy	49	28	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Elizabeth	43	37	--	IIa	--	--	--	III	IIa	I	I	--	I	--	--	--	I	I	I	IIa	IIa	--	--	--	--	--	--
Padma	34	43	--	I	--	--	--	III	IIb	I	I	--	IIa	--	--	--	IIa	I	I	I	I	--	--	--	--	--	--
Sarah	39	46	--	IIa	--	--	--	III	IIa	I	IIa	--	I	--	--	--	I	I	I	III	I	--	--	--	--	--	--
Esther	42	40	--	IIb	--	--	--	III	IIa	IIa	I	--	IIb	--	--	--	I	I	I	III	III*	--	--	--	--	--	--

Note: Consult the Scoring Procedures for the Scoring Range for Each Task.

Raw Pretest Data: Control Group, Wave II

Name	Age as of 10/1/72	Peabody	Raven	Dichotomies	Class Inclusion	Cross Class		Seriation				Seri Corr		Double Ser		Transitivity	Measurement					Conservation					
																						Number		Length		Substance	
						Repro	Transpo	Absolute	Relative	Successive	Additive	(1)	(3) & (4)	Repro	Transpo		Length Comparison	Distance via Reference Length	Distance via Units	Height via Reference Length	Area via Units	Prediction	Deformation	Prediction	Deformation	Prediction	Deformation
Tim	37	33	6	I	I	I	I	I	IIa	IIa	IIa	I	IIb	I	I	IIc	I	I	I	IIa	IIa	I	I	I	I	II	I
Eric D	43	50	7	IIa	I	I	I	III	IIa	I	IIb	IIa	IIb	I	I	IIa	I	I	I	III	I	I	I	I	I	I	I
Daniel	37	37	14	I	III	IIb	I	I	IIa	IIa	IIb	IIa	IIa	I	IIa	IIa	I	I	I	III	I	I	I	I	I	I	I
Evan M	39	42	4	I	I	IIa	IIa	III	IIb	I	I	III	IIb	III	IIb	II	I	I	I	III	I	I	I	I	II-I	I	I
Roger	36	20	7	IIa	II	IIa	IIa	II	IIb	IIc	I	NR	IIb	I	I	I	I	I	I	IIa	IIb	I	I	I	I	I	I
Jeff	38	55	10	IIa	I	I	I	I	I	IIb	IIa	IIb	IIb	I	I	III	I	I	I	IIa	IIb	III	II-I	I	I	II*	III-I
Eric K.	41	46	9	IIa	II*	IIa	I	III	IIa	I	I	I	I	IIb	IIa	III	III	I	IIb	IIa	I	I	I	I	I	II*	I
Steven	41	51	8	IIa	I	III	IIb	I	IIa	IIa	I	IIb	IIb	I	I	IIa	I	I	I	III	IIa	I	I	I	I	I	I
Bruce	44	71	10	IIb	I	IIb	I	IIb	I	III	III	III	III	III	I	III	I	I	I	IIa	I	I	I	I	I	I	I
Lisa	45	44	10	IIb	I	IIa	IIa	III	IIa	I	IIa	IIb	IIb	IIa	I	IIb	III*	I	I	III	I	II	I	I	I	II*	I
Sarah M.	44	56	11	IIb	I	IIa	IIa	III	IIa	IIa	I	III	I	I	I	III	I	I	I	IIa	I	I	II-I	II*	II*I	I	I
Madelain	45	50	14	IIb	I	IIb	I	III	IIa	I	I	I	IIb	I	I	I	III	IIa	IIb	III	IIa	III	I	II*	I	I	I
Julie	41	54	13	IIa	II	I	I	III	III	I	IIa	IIa	IIb	I	I	III	I	I	I	IIa	IIa	I	I	I	I	I	I
Sarah F.	41	49	3	IIa	I	IIa	IIa	III	IIa	I	I	IIb	I	IIa	IIa	IIb	I	I	I	I	I	II*	III-I	I	I	II*	I
Suzanne	45	50	11	I	I	IIb	I	III	IIa	I	I	IIa	IIb	I	I	IIa	IIa	IIa	I	III	IIa	II*	II*I	III	II*I	II*	II*I
Sophie	41	56	9	IIa	I	IIb	IIa	III	I	I	I	I	IIb	I	I	IIc	I	I	I	IIb	I	I	I	II	I	II	I
Sarah I.	44	53	17	IIa	III	III	IIa	III	IIb	III	IIb	III	IIb	I	I	III	I	I	I	III	I	I	I	I	I	I	I

Note: Consult the scoring procedures for the Scoring Range for Each Task.

Raw Post Test Data: Experimental Group, Wave I

Name	Age as of 3/1/73	Peabody	Raven	Dichotomies	Class Inclusion	Cross Class		Seriation				Seri Corr		Double Ser			Measurement						Conservation Number		Length		Substance	
						Repro	Transpo	Absolute	Relative	Successive	Additive	(1)	(3) & (4)	Repro	Transpo	Transitivity	Length Comparison	Distance via Reference Length	Distance via Units	Height via Reference Length	Area via Units		Prediction	Deformation	Prediction	Deformation	Prediction	Deformation
Burton	52	51	8	IIa	II	III	I	III	I	IIb	IIb	III	IIa	I	III	I	III*	I	I	III	IIa		I	I	I	I	I	I
Andrew	52	48	14	III	I	IIa	IIa	III	I	IIa	IIa	I	IIb	I	I	IIc	III	I	IIb	III	I		I	I	I	I	II	I
Paul	64	61	15	IIa	I	III	III	III	IIa	III	III	III	IIb	III	IIb	III	IIa	I	IIa	III	IIa		I	I	I	I	II	I
Michael	56	53	15	III	I	III	IIa	III	IIb	III	III	III	IIb	III	IIb	III	III*	I	IIb	III	IIa		I	II-I	II*	I	III	III R
Peter	56	50	13	IIb	I	III	III	III	IIb	III	III	III	IIa	III	IIb	III	III	I	I	III	III		III	III R	III	III R	III	III R
Stephen	63	62	14	III	I	III	III	III	IIa	III	III	III	III	III	IIa	III	III	I	I	III	III*		III	I	I	I	II	III R
John	61	50	14	IIb	I	I	I	III	I	I	III	I	I	I	I	I	IIa	I	I	III	I		I	I	I	I	I	I
Darrell	60	51	12	IIa	I	IIa	I	III	I	IIa	IIb	IIb	IIb	IIa	I	I	III	I	I	III	I		I	I	I	I	I	I
Peter W.	62	58	10	III	III	III	I	III	IIb	III	III	III	IIb	III	III	III	IIa	I	I	III	I		III	III R	III	III-R	III	III-I
Steven Y	59	57	16	III	I	III	IIb	III	I	III	III	III	III	I	I	III	III*	IIb	IIb	III	I		III	III R	III	II-I	III	III-R
Barbara	59	62	15	IIb	III	III	IIb	III	I	III	III	IIa	III	III	IIb	III	III*	I	IIa	III	III*		III	I	I	I	I	I
Erica	55	54	16	IIb	III	III	III	III	IIb	III	III	III	IIb	III	I	III	III	I	I	III	I		III	III R	III	III R	III	I
Meira	58	44	16	III	I	III	III	III	I	III	III	III	IIb	III	IIb	III	III*	IIa	III	III	III		II	III R	II	III R	III	II-I
Allison	53	52	14	III	I	IIb	III	II	IIb	III	III	III	IIa	III	III	III	III*	IIa	IIa	III	I		III	I	I	I	I	II R
Susan C.	51	44	18	III	I	III	III	III	IIb	III	III	III	IIb	III	IIb	I	IIa	I	I	III	I		II	II R	I	I	I	III-R
KirstenW	55	60	13	IIb	I	III	III	III	IIa	III	III	III	IIb	I	IIb	III	III*	I	III*	III	I		III	III R	III	III R	III	III-R

Note: Consult the scoring procedures for the Scoring Range for Each Task.

Raw Posttest Data: Experimental Group, Wave II

Name	Age as of 10/1/73	Peabody	Raven	Dichotomies	Class Inclusion	Cross Class	Seriation				Seri Corr		Double Seri		Transitivity	Measurement					Conservation					
																					Number		Length		Substance	
						Repro	Transpo	Absolute	Relative	Successive	Additive	(1)	(3) & (4)	Repro	Transpo		Length Comparison	Distance via Reference Length	Distance via Units	Height via Reference Length	Area via Units	Prediction	Deformation	Prediction	Deformation	Prediction	Deformation
Tom	53	54	18	IIb	I	III	III	III	IIa	III	III	III	III	III	III	III	III	I	I	III	III	I	I	I	I	I	I
Matthew	51	51	10	IIb	I	IIa	IIa	III	I	IIc	IIb	IIb	IIb	III	IIa	III	III	I	I	III	I	III	III-II	III	III-I	III	III
Andrew	50	50	8	IIa	I	IIb	IIa	III	IIa	IIa	IIa	IIb	IIb	I	I	I	III	I	I	III	I	III	I	II	I	I	I
Justin	52	58	16	IIb	I	III	IIa	III	III	III	IIa	III	III	III	I	III	III*	III*	IIa	III	I	III	III-R	I	I	III	III-I
Joel	53	70	17	IIa	I	IIa	I	II	IIb	III	III	III	I	III	III	III	III	IIb	IIa	III	IIa	III	III-R	III	I	III	III-R
Kurt	50	63	10	IIa	I	IIa	IIb	III	IIa	IIa	IIb	IIa	IIb	III	IIb	IIc	I	I	I	III	IIa	II	I	I	I	I	I
Chuck	57	40	14	I	I	III	I	III	I	III	IIa	IIb	IIa	III	IIa	III	III	I	I	III	I	I	I	I	I	I	I
James	55	51	14	IIb	I	IIa	I	II	IIa	I	I	III	IIb	I	I	IIc	IIa	I	IIa	IIb	IIb	I	I	II	I	II	I
Reid	53	60	11	IIa	I	IIa	IIb	III	IIb	III	IIb	IIb	IIa	IIa	I	I	III	I	I	III	I	II	I	III	I	I	I
Matt	58	62	16	IIb	II	IIa	I	III	IIa	IIb	IIa	IIb	IIb	III	IIb	III	III	I	I	III	I	II	III-R	III	III-R	III	III-R
Marguerite	46	47	10	IIa	I	IIa	III	III	I	IIa	IIa	IIb	I	IIa	IIa	III	I	I	I	III	I	I	I	I	I	I	I
Gail	50	51	16	IIa	I	IIa	IIa	III	IIb	I	IIa	IIb	IIa	I	I	III	III	I	IIb	III	I	II	I	III	I	I	I
Patricia	57	53	10	IIb	I	IIa	IIb	II	I	IIb	IIb	IIc	IIb	I	I	IIc	III	I	I	IIa	I	I	II-I	I	I	I	III-I
Kathryn	52	66	15	IIb	II	IIa	IIa	III	IIa	III	III	III	IIb	III	IIb	III	III	I	I	IIb	I	I	I	I	I	I	I
Amani	50	46	9	IIb	II	IIa	IIa	III	I	I	IIb	IIb	IIb	IIb	IIa	I	IIb	IIb	I	III	I	I	I	I	I	I	I
Tal	53	51	11	IIa	II*	IIb	III	III	I	III	IIa	III	IIa	I	IIb	III	III	I	I	III	III	I	I	I	I	I	I
Caroline	54	60	20	IIb	II	III	III	III	I	III	III	III	III	III	IIa	III	III	I	I	III	I	II	I	I	I	II	I
Wendy	56	47	9	IIa	II*	I	IIa	II	IIa	I	IIa	IIb	IIb	I	I	IIc	III	I	I	III	I	II*	I	I	II-I	I	I

Note: Consult the scoring procedures for the scoring range for each task.

Raw Posttest Data: Control Group, Wave I

Name	Age as of 3/1/73	Peabody	Raven	Dichotomies	Class Inclusion	Cross Class		Seriation				Seri Corr		Double Ser		Transitivity	Measurement					Conservation Number		Conservation Length		Conservation Substance	
						Repro	Transpo	Absolute	Relative	Successive	Additive	(1)	(3) & (4)	Repro	Transpo		Length Comparison	Distance via Reference Length	Distance via Units	Height via Reference Length	Area via Units	Prediction	Deformation	Prediction	Deformation	Prediction	Deformation
Charles	58	63	22	IIa	I	IIa	III	III	IIa	III	III	III	IIb	III	IIb	III	III	I	III	III	IIb	I	I	I	I	I	I
Michael	54	54	13	IIb	I	IIa	IIa	III	I	IIb	IIa	III	IIb	IIa	I	III	I	I	I	III	I	I	I	I	I	I	I
Eric	66	59	12	IIb	III	IIa	IIb	III	I	III	III	IIa	IIb	III	III	I	III	I	I	III	IIb	I	I	I	II*R	III	III-I
Roan	59	58	13	III	II*	IIa	IIa	III	IIa	IIb	IIa	IIa	IIb	IIa	I	III	III*	IIa	IIa	III	I	I	I	I	I	I	I
Peter K.	54	52	14	III	I	III	III	II	I	III	III	III	IIb	III	IIb	I	IIa	I	I	III	I	II	IIIR	II	I	II	I
Keith L	58	57	18	III	II*	III	III	III	IIa	III	III	III	IIb	III	III	III	III	I	I	III	III	III	IIIR	I	I	I	I
Kayvan	53	56	10	III	I	IIa	I	II	I	III	III	I	IIb	IIa	I	I	IIa	I	IIb	III	IIb	III	I	I	I	I	I
Joshua	56	57	10	IIa	III	IIa	III	II	I	III	III	I	IIb	III	IIa	III	III*	I	I	III	IIb	I	I	I	I	I	I
Kevin	56	47	15	IIa	III	IIa	IIa	III	I	IIc	IIa	I	IIa	I	IIb	III	I	I	I	III	I	II	I	I	I	I	I
Steven T.	62	57	13	III	II*	IIa	IIa	III	I	I	IIb	IIa	IIa	I	I	IIa	I	I	I	IIb	I	I	I	I	I	I	I
Skippy C.	59	62	16	IIb	II*	III	III	III	IIa	III	III	III	III	III	III	III	III*	I	I	III	IIa	III	III	I	I	III	III
Laura	54	55	12	III	I	III	IIb	III	I	III	III	III	IIb	IIa	I	III	I	I	I	III	I	I	I	I	I	I	I
Ann	65	62	16	IIb	II	IIa	IIb	II	I	III	III	III	IIb	III	IIb	III	III*	IIb	IIb	III	IIa	III	IIIR	III	IIR	III	IIIR
Debra	62	46	13	III	II*	IIa	IIa	III	III	III	III	III	IIb	III	IIb	III	IIa	IIa	IIb	III	IIa	III	IIIR	II	IIIR	III	IIIR
Jennifer	54	50	14	III	I	III	IIb	III	I	III	III	III	IIb	III	IIb	III	III*	I	I	III	III	I	I	I	I	I	I
Joella	60	55	12	IIb	III	III	IIb	III	I	III	III	III	IIa	IIb	IIa	III	I	I	I	III	I	III	I	I	I	I	I
Amy	53	47	13	IIa	I	III	III	II	IIa	III	IIb	IIa	IIb	IIa	IIa	III	IIa	I	I	III	I	III	I	I	I	I	I
Lisa	59	52	10	IIb	I	IIa	IIb	III	III	III	III	III	III	III	I	III	IIa	I	I	III	I	I	I	I	I	I	I

Raw Posttest Data: Control Group, Wave II

Name	Age as 10/1/73	Peabody	Raven	Dichotomies	Class Inclusion	Cross Class		Seriation				Seri Corr		Double Seri		Transitivity	Measurement					Conservation Number		Conservation Length		Conservation Substance	
						Repro	Transpo	Absolute	Relative	Successive	Additive	(1)	(3) & (4)	Repro	Transpo		Length Comparison	Distance via Reference Length	Distance via Units	Height via Reference Length	Area via Units	Prediction	Deformation	Prediction	Deformation	Prediction	Deformation
Tim	49	52	16	IIa	II	IIa	I	III	IIa	IIc	III	IIb	IIa	I	I	III	III	I	I	III	IIa	I	I	I	I	I	I
Eric	55	57	16	IIb	I	IIa	IIa	III	IIb	III	IIa	III	IIa	I	I	III	III	I	I	III	III	I	I	I	I	I	I
Daniel	49	62	15	III	I	III	IIa	III	IIa	IIc	III	IIb	IIb	III	I	III	III*	I	I	III	I	I	I	I	I	I	I
Evan	51	46	17	III	II	III	I	III	IIb	IIb	III	IIc	IIb	III	I	III	I	I	I	III	I	I	I	II*	I	I	I
Roger	48	68	19	IIb	II	IIa	IIa	III	IIa	IIc	IIa	IIa	III	IIa	I	III	I	I	I	III	I	II	I	II	I	I	I
Jeff	50	65	18	IIa	I	III	I	III	IIa	III	III	III	IIb	I	I	III	III	I	I	III	I	III	III^{R}	III	II^{I}	III	III^{I}
Lisa	57	55	13	IIb	I	IIa	IIa	III	IIb	III	III	III	III	IIb	IIb	III	III	IIa	IIa	III	IIa	II	III^{R}	I	I	III	III^{I}
Sarah	56	57	15	IIb	I	III	IIa	III	IIa	III	III	III	IIb	III	IIb	III	III*	IIa	IIa	III	I	III	III^{R}	III	III^{R}	III	III^{R}
Madelaine	57	66	17	III	II	III	IIb	III	IIb	III	III	III	IIb	III	IIb	I	III	III	III	III	III	III	III^{R}	I	I	III	III^{R}
Julie	53	59	12	IIb	II	IIa	IIa	III	III	III	III	III	IIb	IIa	IIa	III	III	I	I	III	IIa	I	I	I	I	I	I

Note: Consult the scoring procedures for the Scoring Range for Each Task.

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